# Water Plant Optimization Study

# GRIMSBY WATER TREATMENT PLANT

June 1991





#### WATER PLANT OPTIMIZATION STUDY

Grimsby
Water Treatment Plant

Project No. 7-2012

June 1991



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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of the Environment.

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#### SUMMARY OF FINDINGS AND RECOMMENDATIONS

#### 1.0 INTRODUCTION

This report on the Grimsby Water Treatment Plant Optimization Study was prepared by MacLaren Engineers Inc. on behalf of the Ontario Ministry of the Environment under Agreement dated April 24, 1987.

The project is a result of the Drinking Water Surveillance Program (DWSP) being carried out by the Ministry of the Environment on municipal water supplies. Under this program, which began on April 1, 1986, a continuously updated base of information is being established on Ontario water plants and water quality. The Water Plant Optimization Study (WPOS) program was initiated for each plant entering the program in order to complement the data gathered from the Orinking Water Surveillance Program.

The study approach and detailed Terms of Reference for the Water plant Optimization Study were prepared by the Ministry of the Environment. The purpose of the study is to document and review present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on the removal of particulate materials and disinfection processes.

To maintain a current database of information, it is envisaged that the WPOS report will be updated on an annual basis.

As a supplement to the Water Plant Optimization Study for the Grimsby Water Treatment Plant, a separate report was prepared on the existing waste management practices at the plant. The report includes recommendations for the optimization handling and disposal of wastes generated at the plant and provides first-order cost estimates for the recommended option. The report was prepared by MacLaren Engineers Inc. for the Ministry of the Environment under the title: Wastewater Disposal Study, Grimsby Water Treatment Plant, August, 1988.

#### 2.0 HIGHLIGHTS OF STUDY

#### 2.1 Raw Water Quality

The raw water source for the Grimsby plant is Lake Ontario. Water is drawn from a depth of 3 to 4 m through the main gravity flow intake which extends about 230 m into the lake. A submersible pump, installed in about 2 m of water at the end of an existing pier about 50 m offshore, serves to supply additional water to the plant during the summer period.

Raw water is subject to wide variations in turbidity and bacteriological quality. The water quality at the main intake is influenced by runoff from the nearby Forty Mile Creek and the re-suspension of lake bottom sediments during storm events. Similarly, the water quality at the pier intake is influenced by the turbulence in the lake.

Monthly average raw water turbidities at the main intake for 1984 to 1986 varied from 1.7 to 35.8 NTU; whereas daily average values varied from 0.8 to 144.8 NTU. The pH of the raw water varied from 7.9 to 8.6 units and was found to be at its highest during the algae growing season. Although no data for algae content were available, test results for chlorophyll  $\underline{\mathbf{a}}$  revealed that algae are present in the raw water at low to moderate levels

## 2.2 Flow Measurement

Flow is measured for the following process streams:

- raw water from the pier pump to the pressure filter by orifice plate flow meter;
- treated plant output water by venturi flow meter;
- backwash water used in cleaning of the pressure filters by orifice plate flow meter.

The raw water flow from the low lift pumps is not metered.

Orifice plate flow meters are equipped with flow totalizers and the venturi meter includes low and high flow differential pressure transmitters, totalizer and circular chart recorder.

#### 2.3 Plant Capacity and Process Design

The Grimsby W.T.P. has two treatment trains consisting of a conventional gravity flow filtration section and a pressure filtration section.

The rated capacity of the gravity filtration plant is  $13,600 \text{ m}^3/\text{d}$ .

The plant includes chemical coagulation, two-stage flocculation, sedimentation and dual media filtration.

The pressure filter plant comprises chemical coagulation and single medium sand filters. The pressure filters have a rated capacity of  $5,700 \text{ m}^3/\text{d}$ , and are only operated during the summer during periods of peak demand, since the pier pump intake is not frost protected.

Alum was used as the coagulant in 1984 and 1985, while polyaluminum chloride was used in 1986. Gaseous chlorine, applied in solution form in pre— and postchlorination modes, is used for disinfection. Taste and odour control is achieved by the addition of powdered activated carbon, as necessary.

Sedimentation tank sludges and filter backwash water are discharged directly to the lake through individual drain pipes.

Capacity limitations exist in both sections of the plant. Pressure filters operate on the principle of direct filtration. This process is affected by raw water quality, and when the raw water turbidity exceeds about 15 NTU the rated capacity of 5,700 m<sup>3</sup>/d cannot be sustained on a continuous basis. In the gravity filtration plant, the pretreatment

units are severely overloaded at the rated capacity of  $13,600~\text{m}^3/\text{d}$  resulting in poor performance of the sedimentation units. Also, since there are only two gravity flow filters, it is necessary to reduce raw water flow with one filter out of service in order to prevent overloading of the in-service filter.

During the winter the plant intake is subject to partial blockage by frazil ice which greatly affects plant capacity. At times, during very cold winter nights, ice blockage has been so severe that several backflushes were required resulting in the depletion of the stored water in the distribution system.

#### 2.4 Process Automation

No process automation equipment has been provided at the Grimsby W.T.P. Pumps and all motorized equipment are started and stopped manually. Chemical feed pumps operate at preset constant speed and constant stroke and require manual adjustment for quantitative control of the dosage with varying flow. Only the chlorinators are equipped with flow proportional controllers.

The discharge from the gravity flow filters is controlled by a self-powered mechanical rate control valve.

## 2.5 Plant Operations

The plant operating staff consists of one senior plant operator and three plant operators. The area superintendent of the Region of Niagara is responsible for the treatment process and all activities at the plant. Plant maintenance is the responsibility of the Region's area foreman.

Plant operators are responsible for the day-to-day running of the plant, which is staffed on the basis of two 12-hour shifts per day seven days per week.

# 2.6 Process and Quality Control

The operator on duty maintains the daily log sheet and, at various

chemical treatment, and the results of quality control tests comprising raw and treated water turbidity, odour, temperature, and chlorine residual analyses. Jar tests are occasionally performed using a Phipps and Bird stirring apparatus to determine the optimum coagulant dosage. Routinely though, the coagulant dosage is selected on the basis of experience and past trends.

### 3.0 PLANT PERFORMANCE

#### 3.1 Particulate Removal

In general, the treatment process performed well at the hydraulic loadings and solids levels experienced during the study period. On a monthly average basis, filtered water effluent turbidities ranged from 0.10 to 0.56 NTU regardless of which coagulant was used, alum or polyaluminum chloride. On a daily basis, higher turbidity values, in excess of 1.0 NTU, were experienced on several occasions as a result of rapidly fluctating levels of raw water turbidities. Poor effluent quality was normally contained to one day except for the period of December 27 to 29, 1986, when the effluent turbidity was consistently above 1.0 NTU.

# 3.2 Disinfection

Disinfection of the raw water is achieved by prechlorination and postchlorination. A good record was established for 1984 to 1986; none of the test samples contained fecal coliform organisms and only one sample in 1986 and two in 1985 tested positive for total coliform.

## 3.3 Taste and Odour

Unpleasant taste and odours are encountered during the summer months, and on occasions during other times of the year. These odours are effectively controlled by powdered activated carbon treatment.

## 3.4 Fluoridation

No fluoride treatment is in effect at the Grimsby W.T.P. for the control of dental caries.

#### 3.5 Aluminum in Treated Water

Neither the raw nor treated water is analyzed for aluminum outside of the recently implemented DWSP by the MOE.

In view of the significance of aluminum residuals in the treated water, it is suggested that at least weekly tests be carried out to obtain this information.

#### 3.6 Stability of Water

On the basis of the Langelier Saturation Index, it was determined that the treated water is slightly aggressive during the winter.

#### 4.0 RECOMMENDATIONS

## 4.1 Physical Improvements

- Install a Streaming Current Detector (S.C.D.) to monitor the optimum coagulant dosage as determined in the laboratory by jar tests and/or streaming current titrations.
- 2. Following first-hand experience gained with the operation and performance of a S.C.D., a decision can be reached as to whether automatic dosage control based on a 4 to 20 mA DC output signal from the S.C.D. is warranted. The implementation of this recommendation would require the provision of new chemical feed pumps with automatic speed and stroke adjustment capabilities.
- 3. The application of coagulant at the Grimsby W.T.P. is inadequate; although the change made in 1987 is an improvement over the original feed point for the main raw water supply. Optimization of the coagulation process, and for the most efficient use of the coagulant chem; ical, it is necessary to flash mix the chemical with the raw water at a fraction of a second. This high intensity mixing can best be achieved at the Grimsby plant by installing chemical injector nozzles, one in the 400 mm dia. common discharge header from the low lift pumps and one in the 200 mm dia. raw water header supplying the pressure filters.

- Operate the existing flocculators at higher speed in order to increase the efficiency of floc formation and to maximize utilization of the chemical coagulant.
- 5. The problem with frazil ice formation at the bell mouth of the main intake can be partially overcome by installing a compressed air system consisting of:
  - $1 85 \text{ m}^3/\text{h}$  capacity air blower, 3 kW motor
  - 2 75 mm diameter air line with perforated ring header around bell mouth of intake.
- Continue using powdered activated carbon for the control of taste odour.

#### 4.2 Studies

- 1. The optimum coagulant dosage, which is currently selected on the basis of extensive jar tests and the plant's track record, should be documented including methods of evaluation procedures and actions taken and results, in order to establish a predictive tool. Jar tests results could be plotted (coagulant dosage versus raw water turbidity), in the form of a dosage chart for use by the operators. With time, the chart can be adjusted to reflect the experience of full-scale treatment.
- 2. In an effort to improve the performance of the sedimentation and filtration processes at the Grimsby plant, many tests have been carried out by representatives of chemical suppliers that market coagulation polymers and polymer preconditioned primary coagulants (i.e. HyperI+on<sup>TM</sup> by General Chemical Canada Ltd.). Unfortunately, none of the tests with the exception of PAC1, proved sufficiently successful to warrant further consideration. For this reason it is recommended that the pretreatment process and unit operations at the Grimsby plant be reviewed in detail by a consulting engineer. Such a study should include a second assess-

ment of the use of flocculant aid polymers and other commercially prepared primary coagulants. In addition, an in-depth assessment should be made of existing and required mixing facilities.

In Section E of this report it has been concluded that the use of a cationic polymer flocculant aid would be beneficial and result in improved performance of the treatment process. The investigation recommended herein should confirm whether or not polymer storage and feed equipment for the application of a cationic or non-ionic polymer as a flocculant aid should be installed at Grimsby W.T.P.

- 3. Studies should be carried out to determine the feasibility of operating pressure filters during the winter. Two supply points should be investigated, 1) from the effluent section of the sedimentation tanks, and 2) from the plant's main raw water wet well.
- Effluent turbidity from pressure filters should be monitored on a routine basis.
- Continue to let a filter rest for about 15 minutes after a wash before returning the filter to service, whenever possible.
- Continue to minimize hydraulic surges during start up by slowly opening the filter effluent valve.
- Investigate filtering to drain via the filter drain valve (at low rate) for 15 to 20 minutes as an alternate means of improving filter effluent quality at start-up.
- 3. The efficiency of chlorination in the postchlorination mode can be improved by increasing the available contact time. This could be achieved by chlorinating individual filter effluents from both the gravity flow filters and the pressure filters. Also, considerations should be given to slightly increasing the post-chlorine dosage.

In light of the Region's current expansion and development plans regarding the Grimsby water supply, the concept for increasing the chlorine contact time will need to be considered further. It is therefore recommended that a study be undertaken to establish the feasibility and costs of this proposal.

 The overall efficiency of the chlorination process can be improved by lowering the high raw water pH.

The feasibility of incorporating pH adjustment treatment at the Grimsby plant should be investigated.

10. Raw and treated water should be analyzed periodically for aluminum content. Also, tests should be carried out to establish the levels of total trihalemethanes in the treated water. Since both of these parameters are now being monitored by DWSP, the data should be examined and the future test frequency determined.

## 4.3 Long-Term Modifications

- In order to monitor and record raw water flows, and to permit quantitative pacing of chemicals, a raw water flow meter should be installed on the 400 mm diameter discharge pipe from the low lift pumps. This meter could be of the ultrasonic, time transient type, and should be equipped with a flow indicating controller, totalizer, signal transmitter and flow recorder.
- In order to improve cold weather operations of the flocculation and sedimentation basins, existing tankage should be covered and weather-proofed. Options to be considered are conditional upon the Region's future development plans and include:

## Option 1

Install a low height roof using precast, prestressed, hollow-core slabs, or single or double tees.

#### Option 2

Enclose the entire tankage in a building equipped with all necessary services. Enclosing of the process units would allow for the future installation of mechanical equipment in floc and sedimentation tanks thereby increasing the performance and capacity of these units

 Considerations should be given to the construction of a new and larger intake, properly sited in deep water where the raw water quality is better and more consistent compared with that of the present location.

The existing low lift pumping station also is inadequate in the long-term and will require to be upgraded and expanded.

The above recommendations are conditional upon the Region's future expansion and development plans for meeting future water needs of the service area.

4. In order to meet the increasing water demand of an expanding service area, and in view of the problems associated with a possible expansion of the existing plant, we endorse the Region's current plans for the construction of new water treatment plant on a new site centrally located within the future service area.

#### ACKNOWLEDGEMENTS

Members of the Project Committee for the Grimsby Water Treatment Plant are listed on the fly-sheet of this report. The cordial assistance provided by each of these members during the course of this study is hereby gratefully acknowledged. To all others who have assisted us in any way, we express our sincere thanks.



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#### SYMBOLS AND ABBREVIATIONS

#### Symbols Used

<

%

less than

per cent

```
dav
h
               hour
min.
               minute
                second
               metre
m
mm
               millimetre
               centimetre
cm
m^2
               square metre
m3
               cubic metre
                litro
               millilitre
mL
kg
               kilogram
               milligram
mq
ug/L
              microgram per litre
               litre per hour
L/h
L/min.
               litre per minute
L/s
                litre per second
m/s
               metre per second
m/h
               metre per hour (filtre rate or surface overflow rate
               equal to m^3/h.m^2)
m^3/d
               cubic metre per day
kg/h
               kilogram per hour
°Č
FTU
                degree Celcius
                Formazin turbidity unit
NTII
                nephelometric turbidity unit
ACU
                apparent colour unit
TCU
                true colour unit
A.S.U. per mL
                areal standard units per millilitre
s - 1
                mean velocity gradient, metre per second per metre
rpm
                revolution per minute
V
                volt
Α
                ampere
kVA
               kilovolt ampere
kW
               kilowatt
               greater than
```

#### Abbreviations Used

DWSP Drinking Water Surveillance Program MOE Ontario Ministry of the Environment WPOS Water Plant Optimization Study

A 1 aluminum CaCO<sub>3</sub> calcium carbonate

Cl<sub>2</sub> E.S. chlorine effective grain size

Ū.C. uniformity coefficient Langelier Saturation Index L.I.

MF membrane filter technique for enumerating bacteria in

water

υН expresses the intensity of the acid or alkaline

condition of a solution

SWD side water depth trihalomethane THM TTHM total trihalomethane



INTRODUCTION

AND

TERMS OF REFERENCE



#### INTRODUCTION AND TERMS OF REFERENCE

#### BACKGROUND

The Ontario Ministry of the Environment has instituted a Drinking Water Surveillance Program. The Program began on April 1, 1986 and encompasses all municipal water supplies in Ontario. The primary objectives of the DWSP for Ontario are to establish a reliable database on water quality which will encompass a wide range of parameters, including pesticides and organic compounds, and to maintain information current by continuously updating the database. In connection with the DWSP, a plant investigation and process evaluation study is initiated for each plant entering the program. A major goal of the study is to document information on the plant's process design and operations, and to determine an optimum treatment strategy for contaminant removal at the plant. It is intended to update the study on an annual basis in order to maintain the database current. The information from these studies will allow valid water quality data to be collected. The results will further identify potential problem areas, serve as the basis for remedial action, and provide a framework for defining contaminant levels and trends

#### 2. TERMS OF REFERENCE

A detailed protocol for the Water Plant Optimization Study has been prepared by the Ministry for use by the consultants engaged for the optimization studies. This study of the Grimsby Water Treatment Plant has been conducted in accordance with the protocol. The main objective of the plant investigation and process evaluation study is:

"To review the present conditions and determine an optimum strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes."

To meet this objective, Terms of Reference were prepared by the Ministry (and later re-issued as Rev. 1 on 06/04/87) consisting of eight specific work tasks which require the consultant to examine, in

detail three years of daily and monthly operating data, to prepare a comprehensive assessment of plant operations and the level of performance achieved, and to provide recommendations for short and long term modifications in order to obtain optimum disinfection and contaminant removal. The complete revised Terms of Reference are included at the end of this report as Appendix D.

As a supplement to the Water Plant Optimization Study, the consultant was commissioned to prepare a separate report on the handling and disposal of wastewaters generated at the plant.

#### 3. GRIMSBY WATER SYSTEM

The Grimsby Water Treatment Plant is operated by the Regional Municipality of Niagara to supply drinking water to the Town of Grimsby. The total population of the service area in 1986 was about 14,665.

The main plant design is based on the conventional treatment process for particulate removal comprising pipe flow blending of coagulant, flocculation, sedimentation and gravity filtration. Seasonally operated pressure filters normally are run in the direct filtration mode. Chemical treatment processes consist of coagulation, disinfection and control of taste and odour.

The capacity of the Grimsby water supply is inadequate to meet the increasing water demand by the expanding service area. A plant expansion has been considered but was found not to be feasible in view of the conditions of the existing facilities, some of which date back to the original installation of the water supply, and the inadequate capacity of the intake. For this season, the Region of Niagara is planning to provide an alternate source of supply or to build a new treatment plant located on a new site within the next five years.

SECTION A

RAW WATER SOURCE



### SECTION A - RAW WATER SOURCE

## A.1 SOURCE

The Grimsby Water Treatment Plant is located on the shoreline of Lake Ontario in the Town of Grimsby. Water is drawn from the lake via two intakes:

- i) a gravity intake 450 mm dia. cast iron and steel pipe sections, about 230 m long, with bell mouth concrete intake crib located in about 3 to 4 m of water (this is the plant's main intake);
- ii) a submersible pump at end of the pier (pier pump) discharges via forcemain laid on top of pier to pressure filters in the Pumphouse. The pier pump is located 50 m off-shore in about 2 m of water and is used during the summer months only.

## A.2 QUALITY

Lake Ontario water in the region of the Grimsby Water Treatment Plant main intake is subject to wide variations in turbidity and is generally high in organic pollution as measured by the coliform group of indicator organisms. The water quality is strongly influenced by runoff from the nearby Forty Mile Creek and reflects the lower water quality typically found in near-shore waters of the lake. In addition, the water quality at both intakes may be influenced by wastewater discharges to the lake west of the intakes consisting of:

- i) pressure filter backwash water;
- ii) gravity filter backwash water;
- iii) sedimentation tank sludge;
- iv) wet weather high level overflows from the sewage pumping station located in the park next to the sedimentation tanks.

Raw water analyses are performed at the Ministry of the Environment laboratories and at the plant for physical and chemical parameters. Test results for 1984 to 1986 are presented in the protocol tables for the Optimization Study attached as Appendix C to this report. A summary of the data for several parameters is presented in Table A.1 to express general water quality conditions. A more detailed discussion of various water quality parameters follows.

## a) Physical Parameters

 $\frac{\text{Turbidity}}{1.7 \text{ NTU to a high of about } 35.8 \text{ NTU}.} \text{ Greater fluctuations occurred in daily values which varied from 0.8 NTU to 144.8 NTU}.} \text{ The overall monthly average for the three-year record was } 11.9 \text{ NTU}.} \text{ The higher values of turbidity generally occurred during the winter, spring and fall periods of the year}.}$ 

<u>Colour</u>: Colour is a measure of the clarity of the water. At the Grimsby intake, the apparent lake water colour is influenced significantly by the colour contributed by suspended matter. The data record indicates that apparent raw water colour varied from 1.5 to 45 ACU, and that the monthly average was 8.3 ACU.

<u>Temperature</u>: Raw water temperature is recorded daily at the plant by reading a thermometer located on the low lift discharge pipe. Average monthly temperatures were less than  $9^{\circ}\text{C}$  except for July through September when the average temperature was  $15.8^{\circ}\text{C}$ . During the year, daily extreme values of  $0^{\circ}\text{C}$  to  $22.5^{\circ}\text{C}$  have been observed.

 $\overline{\text{Taste}}$  and  $\overline{\text{Odour}}$ : The raw water odour level is checked informally several times during the day by the operator. The operator reported that odour problems can arise at any time of the year.

## b) Chemical Parameters

 $\underline{\text{pH Value}}$ : The average monthly raw water pH generally was above 3.0 units and ranged from 7.9 to 8.6 units. The highest levels occurred during the algae growing season.

Alkalinity: Total raw water alkalinity during 1984 to 1986 varied from 92.2 to 144.4 mg/L as  $CaCO_3$ . The monthly average alkalinity value for the study period was 99.4 mg/L.

 $\frac{\text{Hardness}}{\text{Hardness}}$ : The monthly average raw water hardness was established as 133.3 mg/L as  $\text{CaCO}_3$ . Little variation was observed in this value which ranged from 121 to 148 mg/L. At this level of hardness the water may be classified as being moderately hard.

## c) <u>Microbiological Parameters</u>

## (i) Bacteriological Water Quality

The record for bacterial raw water quality indicates that the level of total coliform organisms varied widely from 5 to 8,300 counts/100 mL and that the monthly average was 708 counts/100 mL. The overall bacterial population, as measured by the total coliform background test, was considerably higher and had a monthly average for the three years of 22,455 counts/100 mL. Fecal coliform organisms were present in each test and varied from 2 to 1,507 counts/100 mL; the monthly average was 64 counts/100 mL. These results indicate that the source water was polluted and that contamination was of fecal origin.

## (ii) Nuisance Organisms (Algae)

No algae counting data were available for the Grimsby plant. During 1984 and 1985 three to five raw water samples per month were analysed at the Ministry of Environment laboratory for chlorophyll  $\underline{a}$ , and chlorophyll  $\underline{b}$  content. Test results for chlorophyll  $\underline{a}$  which is an indicator of the algae biomass, indicate average monthly values of 1.7 to 36.3 µg/L and a two-year average of 5.4 µg/L. For chlorophyll  $\underline{b}$  the monthly average range was 0.3 to 3.2 µg/L and the two-year average was 1.4 µg/L. Individual test results for chlorophyll  $\underline{a}$  varied from 0.5 to 134.0 µg/L. A concentration of 20 µg/L and above is representative of a moderate level of algae.



TABLE A.1

LAKE ONTARIO RAW WATER QUALITY CHARACTERISTICS
AT THE GRIMSBY WATER TREAMENT PLANT

	3-Yea	r Summary, 1	984 to 1986	
	Range			
·	(Mont	hly Average)	Average	
		25.0	11.0	
Turbidity, FTU	1.7 -	35.8	11.9	
Colour, ACU	1.5 -	45	8.3	
pH, Units	7.9 -	8.6	8.26	
Temperature, °C	0 -	22.5	7.7	
Alkalinity as CaCO <sub>3</sub> , mg/L	92.2 -	144.4	99.4	
Hardness as CaCO <sub>3</sub> , mg/L	121 -	148	133.3	
Total Coliform, (MF) per 100 mL	5 -	8,800	708	
Total Coliform Background,				
(MF) per 100 mL	136 -	125,380	22,455	
Fecal Coliform, (MF) per 100 mL	2 -	1,507	64	
Chlorophyll-a, µg/l	1.7 -	36.3	5.4	
Chlorophyll-b, µg/L	0.3 -	3.2	1.4	



SECTION B

FLOW MEASUREMENT



## SECTION B - FLOW MEASUREMENT

## B.1 METHOD OF MEASURING FLOWS

### Raw Water

Raw water is supplied to the plant from two locations. The majority of flow is conveyed to the treatment facilities via the 400 mm diameter discharge header from the low lift pumps. During periods of peak demand in the summer months, the raw water flow can be increased with the use of a portable submersible pump located at the end of a pier extending into the lake (pier pump). The submersible pump discharges raw water to the plant via a 200 mm pipe laid partially above ground.

Both the low lift pumps and the pier pump can discharge either to the pressure filters or to the gravity sedimentation and filtration plant. However, the two discharge headers are not directly connected and no metering facilities are provided to measure flow from the low lift pumps. A single orifice type water meter is located on a run of pipe which carries water flow from the pier pump and/or the settling tanks to the pressure filters. Since the low lift discharge header bypasses this meter, no record of total raw water pumpage is available. Flow recorded by this meter was not incorporated into this report, since it does not relate to total raw water pumpage.

### Treated Water

The high lift pumps discharge treated water to the distribution system via a 500 mm diameter discharge header. A venturi meter is located on the discharge header in a metering chamber in the yard to the south of the plant. Inside the pumping station on the south wall, a totalizer and circular chart recorder are provided to monitor and record treated water flow.

The treated water meter is reportedly calibrated every six months, regardless of whether flow records are considered suspect, as the meter readings are used for billing purposes. Operations staff log maximum, minimum and total flow daily.

### Filler Backwash Water

Backwash water for the pressure filters is drawn from a 250 mm diameter connection downstream of the treated water meter chamber. This backwash water is metered by an orifice type meter in the low lift pump area and the metered flows are deducted from the daily treated water flow measured by the treated water meter.

Backwash water for the gravity filters is drawn from the clear well below (Clear Well 2). A 250 mm diameter connection to the distribution main on Lakeside Drive serves as standby. Neither of these sources of backwash water is metered.

## Service Water

Plant service water is drawn from within the plant and is not metered.

## B.2 SUMMARY OF FLOW MEASUREMENTS

Daily treated water flows pumped to the distribution system are tabulated in Table 1.1 for 1984 to 1986. These flows appear consistent for the entire record. Minimum daily flows did not always occur on weekends or statutory holidays as would normally be expected. This could be due, in part, to the fact that there is minimal industry within the service area. Therefore, water demand would not be expected to decrease on weekends as markedly as it would in a heavily industrialized area.

A monthly summary of daily average, minimum and maximum flows is given for each year at the end of Table 1.1 and in Table 1.0. The summary shows expected seasonal variations with higher average day flows throughout the summer. The highest average daily flows during the study period were recorded in the summer of 1985, however, average daily flow for the year was less than in 1986. The highest maximum daily flows occurred in July or August each year, and the lowest minimum daily flows occurred in December or January.

The following yearly summary of treated water flows indicates an increase in water flow during the study period, which is expected as the service area increases and the distribution system continues to age.

	Yearly Summary	of Treated Water	Flows, ML/d
	1986	1985	1984
Average Day	6.886	6.876	6.019
Maximum Day	13.406 (July)	14.026 (Aug.)	11.497 (Aug.)
Minimum Day	4.180 (Dec.)	3.441 (Jan.)	4.023 (Dec.)

No comparison of raw and treated water flows can be made to assess the validity of the flow data.

## B.3 PER CAPITA WATER CONSUMPTION

The table below summarizes per capita water consumption for the years 1984 and 1985. Population data were obtained from the Annual Operating Reports for the Grimsby Water Treatment Plant prepared by the Region. A 1986 service population was unavailable and therefore was assumed to be equal to that of 1985. The water consumption figures shown do not include plant service water or backwash water consumed at the plant.

	Average Day Consumption	Service	Per Capita
Year	ML/d	Population	Consumption (Lpcd)
1986	6.886	14,665	470
1985	6.876	14,665	469
1984	6.019	14,221	423

The per capita consumption figures for the three years are at the higher end of the range of 270-450 Lpcd normally used for design purposes. The table indicates that per capita consumption increased from 1984 to 1985 by 46 Lpcd and remained the same for the following year. This increase in per capita consumption from 1984 to 1985 could be due to several factors, including lack of rainfall during the summer of 1985, increased leakage in the distribution system, inaccuracies in water metering and population data, an increase in the unit rate of consumption and, possibly, due to an increase in the ratio of commercial/industrial to residential consumption.

Some representative per capita water consumption records (1981 data) for several communities in Ontario are as follows:

Community	Population Served	ML/d Avr. Flow	Per Capita Consumption (Lpcd)
Ancaster	11 000	2.179	198
Aurora	13 500	7.590	562
Brockville	21 500	19.413	902
Collingwood	11 100	17.251	1,554
Elliot Lake	12 893	10.410	807
Fort Erie	11 904	15.744	1,323
North Bay	45 000	20.429	454
Orangeville	13 034	4.312	331
Owen Sound	12 365	9.533	771
Pembroke	15 125	9.166	606
Smiths Falls	11 679	9.079	777
Wallaceburg	10 667	11.940	1,119

SECTION C

PROCESS COMPONENTS



### SECTION C - PROCESS COMPONENTS

### C.1 GENERAL

Design drawings for the Grimsby Water Treatment Plant were not available. The original water supply works, which includes the Pumping Station and three pressure filters, were expanded in 1957 with the addition of the Filter Building and the sedimentation tanks. The original works were built around 1905.

A simplified Block Flow Diagram in Figure C.1 illustrates the treatment facilities that have been provided.

The gravity filtration section of the plant utilizes the conventional treatment process consisting of in-line chemical addition, two-stage flocculation, sedimentation and gravity dual media filtration. The original design capacity is believed to have been  $6.800~\rm{m}^3/\rm{d}$  when the filters were equipped with a single medium of sand. In December 1982, the original sand filters were changed to dual media, high-rate filters, whereby the design capacity was increased to the currently rated capacity of  $13.600~\rm{m}^3/\rm{d}$ .

Manually cleaned, stationary raw water screens are included in the raw water intake well to screen the water prior to raw water pumping. The raw water (or low lift) pumps discharge to the flocculation/sedimentation tanks where the bulk of the particulate matter is removed. Following sedimentation, the water is filtered through two gravity filters. Filtered water discharges to clear well 2 below the filters, overflows at high level and discharges to clear well 1 in the Pumping Station. High lift pumps, with suction headers directly connected to clear well 1, deliver treated water to the distribution system.

The pressure filters in the Pumping Station, when in operation, are normally supplied with raw water from a submersible pump installed at the end of an existing pier (hence referred to as the pier pump). Raw water is thus treated, following coagulant addition downstream of the

pump, by direct filtration. The combined design capacity of the three pressure filters has been quoted as  $5,700~\text{m}^3/\text{d}$  equivalent to 900~Imperial gallons per minute (gpm), although it is believed that the actual design flow rating is  $4,900~\text{m}^3/\text{d}$  which is equivalent to 900~U.S. gpm. Since raw water turbidity at the pier is highly variable, it is also possible, as an alternative mode of operation to direct filtration, to discharge the flow to the flocculation/sedimentation tanks. With the use of a portable, submersible pump, pressure filters can then be loaded with settled water.

Since the pier pump installation (and the settled water pipe to the pressure filters) is not frost protected, the pressure filters are only operated seasonally during the summer. With reasonably good raw water quality, the full design capacity can be achieved which, during the summer time, increases the total plant capacity to  $19,300 \, \text{m}^3/\text{d}$ .

Chemical treatment is provided in the form of:

- prechlorination of the raw water (low lift pump and pier pump discharges)
- postchlorination of filtered water
- alum coagulation to aid clarification and filtration (polyaluminum chloride was used on a trial basis in 1986)
- powdered activated carbon addition, as necessary, to control taste and odour.

## C.2 DESIGN DATA

A summary of the design data and relevant plant information is presented in Table C.1. The Process Design Schematic in Figure C.4 illustrates the relationship of process components and provides a convenient overview of the sizing and capacities of these components.

## a) Capacity

It is believed the plant was designed with a capacity of  $6,300~m^3/d$ . Following the conversion of sand filters to dual media filters, in

## TABLE C.1

## GRIMSBY WATER TREATMENT PLANT

# DESIGN DATA AND PLANT INFORMATION

The Regional Municipality of Niagara

Grimsby Water Treatment Plant 447 Elizabeth Street

Town of Grimsby, Ontario

(416) 945-4323

## PLANT ADDRESS

Plant Address Municipality Plant Name

Phone Number

YEAR FILTER PLANT OPENED

Gravity Filter Plant opened in 1957

Pressure filters were installed in 1945, while the original water supply works (pumping station, intake) were built around 1905

Lake Ontario

## PLANT CAPACITY

WATER SOURCE

Gravity Filter Plant

Design Capacity Rated Capacity

Design Capacity Pressure Filters

Rated Capacity

Combined Rated Plant

Capacity

 $6,800~m^3/d$   $13,600~m^3/d$  (following conversion of sand filters to dual media filters in December 1982

4,900 m<sup>3</sup>/d 5,700 m<sup>3</sup>/d

19,300 m3/d

## INTAKE

Crib

Intake

· Capacity

Raw Water Well

Pier Pump Intake

ı

· Pump Discharge Pipe

## RAW WATER SCREENS

LOW LIFT PUMPING STATION

Pumps

Station Capacity

90° elbow concrete pipe with bell mouth opening 2.44 m water depth at crib is 3 to 4 m

450 mm dia. cast iron and steel pipe buried on lake bed length of intake is about 230 m

- approx, dimensions: 2.74 m W x 3.66 m L x 3.96 m D; 2.74 m volume of intake is about 36.6 m<sup>3</sup> 159 L/s @ 0.9 m max. drawdown SWD; volume 39.7 m3 max.

- 1 Flygt, portable, submersible pump; Model C 3152 HT, capacity 66 L/s @ 12.7 m TH; 14 kW motor; about 2 m

200 mm dia. x 50 m off-shore, plastic pipe laid on top of submergence

- 4 stationary screen, 1 spare, manually cleaned

- 2.65 m L x 1.19 m D, 6.35 mm mesh size

# - 3 horizontal, centrifugal pumps - No. 1 - 47.3 L/s @ 12.2 m TH; electric induction motor

11.2 kW

- No. 2 - 159.0 L/s @ 11.9 m TH; dual drive - electric induction motor - 30 kW, 4 cyl. gas engine

 summer - 15,670 m³/d firm, 29,400 m³/d installed - No. 3 - 68.1 L/s @ 12.2 m TH; 4 cyl. gas engine - winter - 9,970 m³/d firm, 23,700 m³/d installed

## RAPID MIXING

Before 1986

Atter 1986

Pier Pump Intake

chemicals added directly to low lift pump suction pipe

directly injected into raw water pipe downstream of pumps coagulant addition point moved to Pumping Station and inlet in raw water well

powdered activated carbon and chlorine solution continued to be added in raw water well

chemicals added by direct injection to discharge pipe downstream of pump near the plant

## FLOCCULATION

Number of Tanks Dimensions per Cell Volume Detection Time

Flocculators Type/Number

• Drive

· Motor Rating

. G Value

· Gt Product

- 2 tanks with 2 cells in series in each - 6.10 m W x 3.05 m L x 3.50 m D, 3.05 m SWD

- 6.10 m W x 3.05 m L x 3.50 m D, - 56.75 m<sup>3</sup> per cell, 227 m<sup>3</sup> total

48 min. design, 24 min. rated

2 horizontal shaft paddle flocculation units equipped with 2 sets of paddle units per cell, 1.98 m dia. x 2.44~m L

2 shafts driven by single, variable speed, motorized drive through chain and sprocket assemblies by Vari-Drive

- 1.12 kW

- 49 s<sup>-1</sup> @ max. speed, about 5.1 s<sup>-1</sup> at current 20% max. operating speed

- 14,700 design @ 20% speed, 7,350 rated @ 20% speed

## SEDIMENTATION

Surface Overflow Rate Dimensions per Tank Number of Tanks Detention Time Effluent Pump Volume

1 Flygt, portable, submerisble pump, Model C 3152 HT - 6.10 m W x 24.38 m L x 3.50 m D, 3.05 m SWD capacity 66 L/s @ 12.7 m TH, 14 kW motor - 453.6 m³ per tank, 907.2 m³ total 0.95 m/h design, 1.9 m/h rated 3.2 h design, 1.6 h rated

## GRAVITY FILTERS

Rate of Flow Controller Number of Filters Surface Area Filter Rate Dimensions

Media

Surface Wash Underdrains

Wash Water Rate Backwash Pump

· Trough Elevation

self-powered mechanical rate of flow control valve by 2 high rate, dual media filters (anthracite and sand) 380 mm anthracite, E.S. = 0.85 to 0.95, U.C. ≤1.7 - 4.7 m/h design, 9.4 m/h rated flow - 5.5 m W x 5.5 m L x 3.07 m D - 30.25 m<sup>2</sup> per filter, 60.5 m<sup>2</sup> total Simplex

600 mm rise per minute max. or 36 m/h @ 11.6 m TH 710 mm above top of anthracite filter

250 mm sand, E.S. = 0.53 - 0.60 mm, U.C. = 1.4  $\,$  250 mm graded gravel, 5 layers of 25 mm to 1.8 mm size rotary, straight arm Palmer sweeps, 5.03 m dia., 1 per

Leopold Block

1-2 speed, vertical turbine pump capacity 303 L/s max. 11.6 m TH, 44.76 kW motor

## PRESSURE FILTERS

3 single medium sand pressure filters by Permutit 200 mm dia. distribution system header 14 m<sup>2</sup> per filter, 42 m<sup>2</sup> total 4.88 m/h design, 5.65 m/h rated 36.6 m/h rise rate design 2.44 m dia. x 7.62 m L each Number of Filters Wash Water Rate Surface Area Filter Rate Dimensions · Source

## CLEAR WELL

open top, below pressure filters in Pumping Station, 480 m<sup>3</sup> below gravity filters in Filter Building, 355 m3 capacity 835 m³ (fixed storage) capacity Total Storage Capacity Clear Well 1 Clear Well 2

## HICH LIFT PUMPS

Type/Number

1 vertical turbine pump, with high thrust electric motor No. 1 - 28.4 L/s @ 64 m TH (33.5 m for single stage), 56 kW - 1-2 stage, horizontal, centrifugal pump, electric induction 3 horizontal, centrifugal pumps, 2 with electric induction - No. 2 - 68.2 L/s @ 97.5 m TH, 93.3 kW motor - No. 3 - 68.2 L/s @ 97.5 m TH, 93.3 kW motor - No. 4 - 68.2 L/s @ 97.5 m TH, 6 cyl. diesel engine drive - No. 5 - 56.8 L/s @ 97.5 m TH, 93.3 kW motor - No. 5 - 56.8 L/s @ 97.5 m TH, 93.3 kW motor - 19,150 m³/d firm, 25,000 m³/d installed motors and 1 with diesel engine drive

Station Capacity

## CHEMICAL PROCESSES

- Chlorination
- Chemical Applied Prechlorination
- Postchlorination
- Storage
- Scale
- Chlorinators

- daseous chlorine in solution form
- low lift pumps common discharge header
- inlet to clear well 1: 1) in pipe from gravity filters, pier pump discharge header

2) to bottom of well

- 68 kg chlorine cylinders, 5 in service, 1 spare, 7 empty 3 2 cylinder scales by W & T, 2 for pre- and 1 for
  - 2 22 kg/d V-Notch, A731 W & T chlorinators for postchlorination service
    - 1 9 kg/d V-Notch, V-100 W & T chlorinator for postchlorination service prechlorination service

## Chemical Applied Coaqulation

- · Application Point

- Storage
- Transfer Pump

- before January 1986 liquid alum (aluminum sulphate) was used as the coaqulant
- before 1986 at pump suction inlet in raw water well and - after January 1986 polyaluminum chloride (PACl) was used in discharge header from pier pump
- after 1986 application point in raw water well was moved to common discharge header from low lift
  - 1 20.5 m³ bulk storage tank, 2.74 m dia. x 3.66 m H pumps in Pumping Station
    - 1 175 L day tank, 0.56 m dia. x 0.86 m H
- 1 coagulant transfer pump to day tank, manually controlled, 50 mm dia. suction x 38 mm dia. discharge

## (cont'd) CHEMICAL PROCESSES

TABLE C.1 - DESIGN DATA AND INFORMATION (cont'd)

Coagulation (cont'd)

· Before 1987 Metering Pump

- 1 - 4.9 L/h W & T A745 diaphragm pump (duty pump), 60 W

motor

· After 1987

· Dry Alum Feeder

Taste and Odour Control

- Chemical Applied
- Storage
  - Feeder

a 2nd coagulant metering station was established in the low lift pump room of the Pumping Station including: 1 - 175 L day tank, 0.56 m dia. x 0.86 m H, 1 M & T pump (from Screen House), and 1 additional BIF 1210-04 diaphragm pump similar 1 W & T dry alum feeder is available in the Screen House - pumps include 3-step pulley for manual speed adjustment - 2 - 9 L/h to 33 L/h BIF 1210 - 04 diaphragm pumps - stroke can be adjusted manually over 0-100% range for use during emergency conditions in capacity to existing (standby), 124 W motor

- powered activated carbon in slurry form applied to the raw
- bagged storage of powdered activated carbon
- 1 BIF screw type dry volumetric feeder with slurrying tank, 45 kg max. Toledo scale, hopper, 44 mm dia. feed screw, 130 L slurry tank

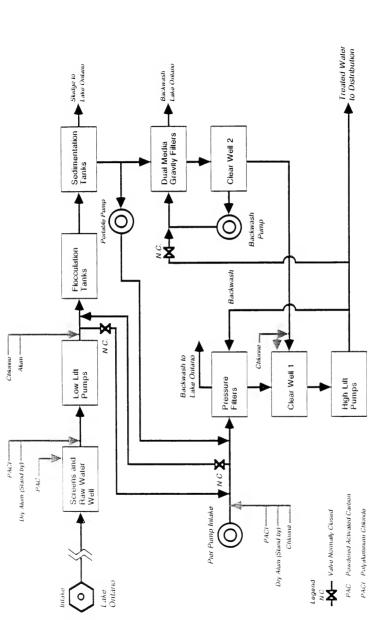


Figure C.1
GRIMSBY WATER TREATMENT PLANT
Block Flow Diagram

December of 1982, the currently rated plant capacity of  $13,600 \text{ m}^3/\text{d}$  was established.

With the installation of the pier intake and three pressure filters, with a design rating of  $4,900 \, \text{m}^3/\text{d}$ , the plant capacity during the summer time was initially increased from  $6,800 \, \text{m}^3/\text{d}$  to  $11,700 \, \text{m}^3/\text{d}$ .

The pressure filters were found to be capable of some overload capacity and have thus been rated at  $5,700 \text{ m}^3/\text{d}$ . During the summer, therefore, with good raw water quality the existing combined rated plant capacity of the Grimsby Water Treatment Plant is  $19.300 \text{ m}^3/\text{d}$ .

The maximum average day raw water flow treated at the plant was established in August 1985 at  $14.026 \text{ m}^3/\text{d}$ .

## b) Capacity Limitations

Pressure filters operate on the principle of direct filtration. Capacity for this process is sensitive to raw water quality, turbidity and algae content, and the level of the coagulant dose. With high raw water turbidity (generally above 15 NTU), therefore, the rated capacity of 5,700  $\rm m^3/d$  cannot be sustained on a continuous basis. In ar attempt to overcome this problem, flow from the pier pump intake can be re-directed to the pretreatment (flocculation and sedimentation) section of the main plant before filtering by the pressure filtration units.

With the main treatment plant (pretreatment followed by gravity filtration), problems have been encountered at high flows during the summer months (at the rated plant capacity of 13,600  $\rm m^3/d$ ) with impaired raw water quality (high raw water turbidity and high algae counts). Problems encountered stem from the poor performance of the sedimentation tanks which are hydraulically overloaded, and the resultant high solids loadings of the filters. A further operational problem exists during backwashing of the two filters. With one filter out of service, raw water flow has to be reduced in order to prevent the in-service filter from being significantly overloaded. Also, during the winter capacity is seriously reduced (in the order of 5,000 to 7,000  $\rm m^3/d)$  as a result of frazil ice blocking the intake and because of poor performance achieved in the coagulation and flocculation of cold water.

## C.3 PROCESS COMPONENT INVENTORY

### a) Intake

The plant is served by two intakes, the main intake which is operational all year, and the pier pump intake which can be operated only during the warm weather period of the year.

The main intake (or gravity intake) consists of sections of 450 mm dia. cast iron and steel pipes buried on the lake bottom. The intake pipe is about 230 m long and is fitted with a bell mouth concrete intake crib. The crib opening is 2.44 m in diameter and is located in 3 to 4 m of water. The original bar screen over the opening has been removed because the screen tended to plug up with frazil ice.

The main intake capacity is 159 L/s (13,738 m<sup>3</sup>/d) at a maximum drawdown of 0.9 m and has a volume of about 37 m<sup>3</sup>.

The raw water suction well in the Screen House has a capacity of about  $40\ m^3$ . Facilities exist for backflushing the intake.

Problems have been encountered with the operation of the gravity intake because of its location in shallow water, close to the shore, and next to the outlet of the Forty Mile Creek. During the winter frazil ice is a serious problem that affects the capacity of the intake. At other times, especially during and after rainstorm events in the fall and spring, raw water quality if subject to wide fluctuations in turbidity which can affect the filtered water effluent quality.

The pier pump intake consists of a submersible pump, capacity 66 L/s at 12.7 m total head, with a 200 mm dia. forcemain laid on top of the pier. The pump at the end of the pier is about 50 m off-shore and is located in about 2 m of water.

The pier pump intake, although acceptable in case of emergencies, cannot be considered suitable as a permanent arrangement since the lake water quality at the location of the pump is highly variable and subject to contamination from on-shore runoff and other point-source discharges.

### b) Raw Water Screens

Stationary raw water screens are installed in the raw water well. Four screens measuring 2.65 m long x 1.19 m deep are stacked vertically, one on top of the other, to separate the inlet from the pump suction well. Screens are fabricated of wooden frames with 5.35 mm wire mesh, and are cleaned manually with a hose on the outside of the Screen House.

## c) Low Lift Pumping

Three low lift pumps are installed in the original Pumping Station. The pumps are of the horizontal, centrifugal design and take suction from the raw water well in the Screen House. A common 250 mm dia. suction header serves pumps 1 and 3 and a 400 mm dia. header serves pump 2.

Pump drivers include electric induction motors and direct gasoline engine drives as shown in Table C.2 and listed below:

- Pump 1 12.2 kW electric motor
- Pump 2 dual drive, 30 kW electric motor and 4 cylinder gasoline engine
- Pump 3 4 cylinder gasoline engine.

The capacity of the low lift pumps is given in Table C.2.

The portable pier pump, also listed in Table C.2, has a submersible electric motor rated at  $14\ kW$ , and a capacity of  $66\ L/s$  at  $12.7\ m$  total head

Exclusive of the pier pump, the installed low lift station capacity is  $23,700 \, \text{m}^3/\text{d}$ . With the largest pump out-of-service, the firm pumping capacity is  $9.970 \, \text{m}^3/\text{d}$ .

The pumps are operated manually from local individual pump start/stop pushbutton stations. Pump selection is based on the water level in clear well 1 obtained from a level indicator located in the low lift pump room. There are no alarms to indicate high or low level in the clear well.

## d) Rapid Mixing

There are no formal rapid mixing facilities at the Grimsby Water Treatment Plant. Before 1987 chemicals in solution form were added to the process flow at the following points:

- alum or PAC1: discharged to the pump suction inlet in the

raw water well

- dry alum: mixed with water to form solution/slurry and

dripped onto the water surface in the raw

water well

- powdered activated slurried and dripped onto water surface in

carbon: raw water well

chlorine solution

· prechlorination: injected into common discharge header from

low lift pumps

- postchlorination: direct discharge to inlet end of clear well 1

- pier pump intake: coaquiant and chlorine solution injected into

discharge pipe downstream of pump (under the

lawn before the water enters the plant).

TABLE C.2

## RAW WATER PUMPS

Pump No.	Capacity L/s	Head m	Туре	Motor Rating, kW	Manufacturer Pump/Motor
1	47.3	12.2	horizontal, centrifugal	11.2	DeLaval Westinghouse
2	159.0	11.9	horizontal, centrifugal	30 plus gas drive	DeLaval Westinghouse motor Continental Motors engine
3	68.1	12.2	horizontal, centrifugal	gas drive	OeLaval Fairbanks Morse engine
Pier Pump	66	12.7	submersible	14	Flygt

## Notes:

Installed Station Capacity

(excluding pier pump): 23,700 m³/d

Firm Station Capacity: 9,970 m<sup>3</sup>/d

After 1986, a second coagulant metering station, coagulant day tank and two metering pumps, for the main treatment stream was established in the low lift pump room of the Pumping Station. From then on, coagulant solution was applied by direct injection into the common raw water discharge header immediately downstream of the pumps. The application of coagulant to the pier pump discharge was not changed.

Originally, mixing of coagulant and raw water was achieved in the suction piping, the low lift pumps, and in the discharge piping to the flocculation basins. The vigorous mixing achieved in the volutes of the pumps was found to be detrimental to the pre-formed floc hence the application point was relocated after the pumps.

## e) Flocculation

Each of the two flocculation tanks is divided into two cells for two-stage mechanical flocculation.

Cell dimensions are:

- cell 1: 6.10 m W x 3.05 m L x 3.50 m D
- cell 2: 6.10 m W x 3.05 m L x 3.50 m D.

The side water depth (SWD) at the design flow rate is 3.05 m.

Flocculating mechanisms consist of two horizontal shaft paddle flocculation units equipped with two sets of paddle units per cell. The two flocculators are driven by a single, variable speed, motorized drive through chain and sprocket assemblies.

The motor rating of the flocculator drive and process design parameters are presented in Tables C.3 and C.4. It will be noted that the flocculator achieves a mean velocity gradient of  $5.1~\rm s^{-1}$  in each cell at the current speed setting of 2 on the vari-drive. The detention time

varies with flow and ranges from 78 minutes to 24 minutes for minimum to maximum flows as represented by the minimum day for 1986 and the rated plant capacity of  $13,600 \, \text{m}^3/\text{d}$ . At the design flow rate the detention time is 48 minutes. The Gt product varies with detention time and is listed in Table C.4.

## f) Sedimentation

Sedimentation tanks each measure 6.10 m wide x 24.38 m long x 3.50 m high and have an operating side water depth of 3.05 m at the design flow rate. The volume per tank is  $453.6 \text{ m}^3$  and the resultant detention times and overflow rates for the various plant flows are as follows:

		Surface
Plant Flow, m <sup>3</sup> /d	Detention Time, h	Overflow Rate, m/h
4,180 - minimum	5.2	0.59
6,800 - design	3.2	0.95
13,600 - rated	1.6	1.90

The sedimentation tank outlet consists of three effluent launders with a total weir length of 17.68 m and a resultant weir overflow rate of 192.3 m<sup>3</sup>/d per metre length of weir.

Settled water is conveyed by gravity to the gravity filters. In addition, a portable submersible pump has been installed in the sedimentation tank effluent channel whereby settled water can be pumped to the pressure filters. The system is not frost protected and is only used during the summer as required. The pump, Flygt Model C 3152 HT, has a capacity of 66~L/s at a total head of 12.7~m; the motor rating is 14~kW.

Sedimentation tanks are open-top, outdoor tanks, without sludge collection mechanisms.

## TABLE C.3

## FLOCCULATOR SPECIFICATION

Manufacturer	Vari-Orive
Туре	Horizontal shaft paddle flocculator
Number of units	2, one each with common shaft serving primary cells of tanks 1 and 2 and secondary cells of tanks 1 and 2 $$
Paddle units	$2$ sets per cell, $1.98\ m$ dia. x $2.44\ m$ L, with $4$ pipe arms containing $2$ paddles on each arm consisting of 50 mm x 150 mm wooden planks
Drive	Single, variable speed, motorized drive unit with chain and sprocket assemblies
Motor rating	1.12 kW
Speed settings	0 to 9, by selector switch on speed reduction $% \left( 1\right) =\left( 1\right) ^{2}$ gear unit .
G Value	49 s-1 maximum, other calculated values are:
	- $26.7 \text{ s}^{-1}$ at speed setting $6$
	- $14.6 \text{ s}^{-1}$ at speed setting $4$
	- $5.1 \text{ s}^{-1}$ at speed setting 2

TABLE C.4
FLOCCULATION PROCESS DESIGN

Plant Flow	Detention Time, min.	Speed Setting	G Value	Gt Product
4,180 - minimum¹	78	2	5.1	23,900
6,800 - design <sup>2</sup>	48	2	5.1	14,700
13,600 - rated <sup>3</sup>	24	2	5.1	7,350

<sup>1</sup> Minimum day for 1986

 $<sup>^2</sup>$  Approximately equal to 1986 average day of  $^{-}6,886~\text{m}^3/\text{d}$ 

 $<sup>^3</sup>$  Approximately equal to 1986 maximum day of 13,406  $\mathrm{m}^3/\mathrm{d}$ 

## g) Filters

## (i) Gravity Filters

The main plant has two dual media, gravity filters located in the Filter Building. They are square in plan dimensions and include one wash water gullet along the inlet side of each filter. Filter controls are of the mechanical design by the Simplex Valve Company and feature an operating console at the front (outlet end) of the filter on the main floor and a self-powered mechanical rate of flow control valve on the effluent piping in the basement pipe gallery. The filters operate on the principle of constant rate filtration.

Filter dimensions are 5.5~m wide by 5.5~m long by 3.07~m deep; the wash water gullet is 0.91~m wide. The wash water trough weir elevation is 1.854~m above the floor of the filter bay and 0.710~mm above the top of the anthracite.

Each filter has a surface area of  $30.25~\text{m}^2$  and the total area for the two filters is  $60.5~\text{m}^2$ . The filter rate at the design flow rate is 4.7~m/h and 9.4~m/h at the rated plant capacity.

The 250 mm deep Leopold Block underdrains are covered with five layers of graded gravel ranging in size from 25 mm to 1.8 mm with a total depth of 250 mm. The filter media consists of a layer of sand and anthracite with the following characteristics:

Media	Depth, mm	E.S., mm	<u>U.C.</u>
anthracite	380	0.85 to 0.95	<1.7
sand	250	0.53 to 0.60	1.4

Each filter is equipped with one  $5.03\,\mathrm{m}$  diameter rotary, straight arm, Palmer sweep surface agitator. Filters are backwashed by a single two speed wash water pump capable of a maximum wash water rise rate of 600 mm per minute equivalent to  $36\,\mathrm{m/h}$ .

### Wash Water System

The filter pipe gallery includes one two speed vertical turbine pump by Peerless Pump Division, driven by an electric induction motor manufactured by U.S. Motor Corp.

The pump has a maximum capacity of 303 L/s at a total head of 11.6 m. The motor rating is 44.76 kW. The pump draws water from the clear well below the filters (clear well 2). A 250 mm diameter connection to the distribution main on Lakeside Drive serves as standby.

### Filter Instrumentation

No analogue or digital filter instrumentation equipment exists. Filters are operated manually from the filter console. A self-powered mechanical filter rate controller (Simplex valve) is installed on the filter effluent piping.

## (ii) Pressure Filters

In parallel with the gravity filtration plant, there are three pressure filters installed in the Pumping Station. These filters, manufactured by The Permutit Company, are 2.44 m in diameter by 7.62 m long, and have an area of  $14\ m^2$  per filter. They include a single layer of sand and operate at a design filter rate of 4.88 m/h.

Backwash water is drawn from a 200 mm diameter main connected in the yard to the high lift pump discharge pipe downstream of the treated water flow meter. Sufficient flow is available to meet the design wash water rate of 36.6 m/h. Backwash water consumption is metered by a BIF orifice type flow meter installed in the 200 mm diameter supply main.

## h) <u>Clear Well</u>

The plant has two clear wells, clear well 1 below the pressure filters in the Pumping Station with a capacity of  $430~\rm{m}^3$  and clear well 2 below

the gravity filters in the Filter Building with a capacity of  $355 \text{ m}^3$ . The combined clear well storage capacity is  $835 \text{ m}^3$  which provides a detention time of 1.47 h at the rated plant capacity of  $13.600 \text{ m}^3/\text{d}$ .

## i) High Lift Pumping

The high lift pump room in the Pumping Station is equipped with four horizontal centrifugal pumps, three of which are driven by electric induction motors and one by a direct coupled diesel engine drive. A fifth high lift pump is installed in the low lift pump room above the clear well. this pump is a vertical turbine pump driven by a high thrust electric motor. Pump capacities and motor ratings are tabulated in Table C.5.

The installed high lift station capacity is  $25,000 \text{ m}^3/\text{d}$  at a total head of 97.5 m except for pump 1 which has a rated head of 64 m. With the largest pump out of the service, the firm station capacity is  $19,150 \text{ m}^3/\text{d}$ .

No standby power is available to run treated water pumps during an emergency power outage. Standby capacity of 68.2 L/s at the design head or 5,900 m<sup>3</sup>/d is provided by pump 4 with the direct diesel engine drive

Pumps discharge into a 500 mm diameter distribution header. A venturi flow meter is located on the header in a chamber in the yard to the south of the Pumping Station. In the pump room a BBC Brown Boveri totalizer and circular chart recorder are provided to monitor and record treated water flow.

Local pushbutton stations are provided for manual operation of the pumps.

## j) Backwash Treatment and Sludge Disposal

There are no facilities for the treatment and disposal of plant process wastes.

Raw water screens are washed outdoors where the wash water and screened solids just discharge to the ground.

Backwash water from the pressure filters and the gravity filters are discharged via individual shore outfalls to the lake.

Similarly, settled sludge from the sedimentation tanks is discharge via a separate shore outfall to the lake. This is done intermittently four times per year.

Reference is made to Figure C.3 for an illustration of the locations of these outfalls.

### k) Standby Power

There is no standby power at the plant. Two low lift pumps and one high lift pump can be operated during power outages with gasoline and diesel engine drives.

## C.4 CHEMICAL SYSTEMS

## C.4.1 LIQUID CHEMICAL FEED EQUIPMENT

## a) Liquid Coagulant

Before January 1986, liquid alum was used as the coagulant. For the remainder of 1986 polyaluminum chloride (PAC1) was used on a trial basis. The two coagulants have similar physical properties and the same storage and feed equipment was used. The equipment that was in use at the time of the site inspection on December 16, 1986 is as follows:

- $1 20.5 \, \mathrm{m}^3$  bulk, PVC lined, wood stave storage tank,  $2.74 \, \mathrm{m}$  dia. by  $3.66 \, \mathrm{m}$  high
- 1 175 L FRP day tank, 0.56 m dia. by 0.86 m high

TABLE C.5
TREATED WATER PUMPS

				Motor	Manufacturer
	Capacity	Head		Rating	Pump
Pump No.	L/s	m	Type	kW	Motor
1	23.4	64	2 stage,	56	DeLava1
			horizontal,		Westinghouse
			centrifugal		
2	68.2	97.5	horizontal,	93.3	DeLaval
			centrifugal		Westinghouse
2	60.0	07.5		22.2	2.4
3	68.2	97.5	horizontal,	93.3	DeLaval
			centrifugal		English Electric Co.
4	68.2	97.5	h i 1	C1	Data and 1
4	08.4	97.5	horizontal,	-	
			centrifugal	diesel	Continental Diesel
5	56.8	97.5	wantinal	93.3	Peerless
3	30.8	3/.5	vertical	33.3	
			turbine		U.S. Electric Motors

# Notes:

Installed Capacity: 25,000 m<sup>3</sup>/d

Firm Capacity: 19,150 m<sup>3</sup>/d

- 1 coagulant stock solution transfer pump
- 3 chemical dosage pumps:
  - · 1 4.9 L/h Wallace and Tiernan A745 diaphragm pump
  - · 2 9.0 to 33 L/h BIF 1210-04 diaphragm pumps
- 1 Wallace and Tiernan dry alum volumetric feeder with slurry tank.

Dosage pumps include 3-step pulleys for manual speed adjustment. The pump strokes are manually adjustable over a 0 to 100% range.

All equipment was located in the Screen House and coagulant was applied to the raw water well and to the pier pump discharge.

The feed rate of each pump was set by manually adjusting the speed and stroke length of the pump. No controls for the automatic pacing of coagulant dosage were provided.

During 1986, with PAC1 as the coagulant, dry alum was used as a standby coagulant.

Subsequently, a second coagulant feed station was established in the low lift pump room of the Pumping Station. This station consists of one day tank of similar capacity to the original tank in the Screen House and two chemical dosage pumps, the Wallace and Tiernan pump from the Screen House and one additional BIF 1210-04-9101 pump with the same capacity as the two existing pumps.

At the new location chemical coagulant solution is applied by direct injection into the common discharge header from the low lift pumps. Again, dosage is manually set by selecting a pump speed (one of three) and adjusting the stroke length of the pump. No proportional-to-flow pacing equipment was provided.

#### b) Powdered Activated Carbon

A powdered activated carbon slurry can be applied to the raw water well for the control of taste and odour.

Feed equipment available consists of a BIF dry volumetric feeder with slurrying tank situated over the raw water well. Dosage is manually set by the operator based on the treated water flow rate.

#### C.4.2 GASEOUS CHEMICAL FEED EQUIPMENT

#### Chlorine Gas

Chlorine gas in solution form is applied for pre and postchlorination. Application points are:

- prechlorination: 1) in common discharge header of low lift pumps
  - 2) in discharge line from pier pump
- postchlorination: 1) at inlet pipe to clear well 1
  - 2) directly to bottom of clear well 1 at inlet.

## Storage Equipment

- 13 68 kg chlorine cylinders, 5 in service, 1 spare, 7 empty
- 3 2 cylinder weigh scales by Wallace and Tiernan,
  - 2 for prechlorination service and 1 for postchlorination.

### Feeders

- 2 22 kg/d Wallace and Tiernan V-Notch, A731, chlorinators for prechlorination service
- 1 9 kg/d Wallace and Tiernan V-Notch, V-100, chlorinator for postchlorination service.

Feeders are equipped with proportional-to-flow controls. All three chlorinators are interchangeable by means of valving on the chlorine feed piping.

The chlorine room, located on the west wall of the Pumping Station, is monitored for gas leakage by a "Chloralert" Fisher and Porter gas in air detector.

#### C.5 SAMPLING

Raw and treated water taps are available at the laboratory sink. All other water samples, required for process monitoring are collected manually.

# C.6 PROCESS AUTOMATION

No instrumentation equipment has been provided for automatic control of the operation of the water treatment plant and pumping equipment apart from the chlorinators, which are equipped with automatic quantitative pacing controls relative to treated water flow.

All plant operations, therefore, are essentially manual. A self-powered mechanical rate control valve, one on each of the discharge headers from the gravity filters, maintains constant filter rate.

This valve will automatically close when a backwash is initiated. Upon filter start-up the valve will automatically open at a gradual rate until the established filter rate is reached.

## C.7 EMERGENCY STANDBY OPERATION

In the event of a power failure plant operations will shut down. The diesel driven high lift pump can be operated for some time until the volume in clear well 1 is depleted.

Although two of the low lift pumps are equipped with gasoline powered engine drives, they cannot be used during a power outage because chemical feed equipment would be out of service.

### C.8 DRAWINGS

## a) Plant Drawings

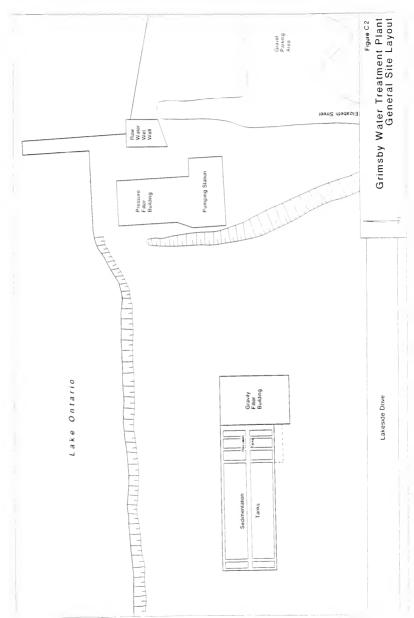
Design drawings were not available for the Grimsby Water Treatment Plant. A sketch of the general plant layout and a process and piping diagram were prepared for the purpose of this report. These drawings are included herein as Figures C.2 and C.3.

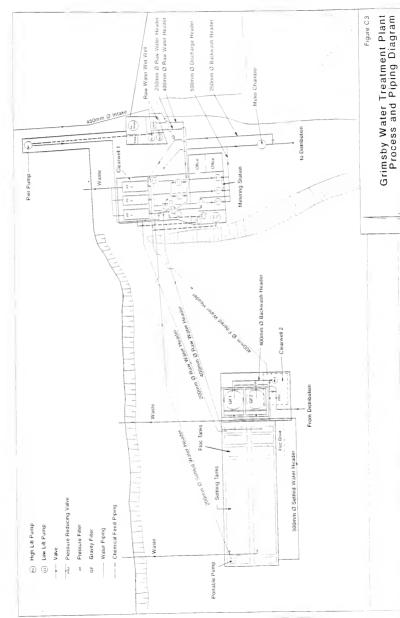
#### b) Process Design Schematic

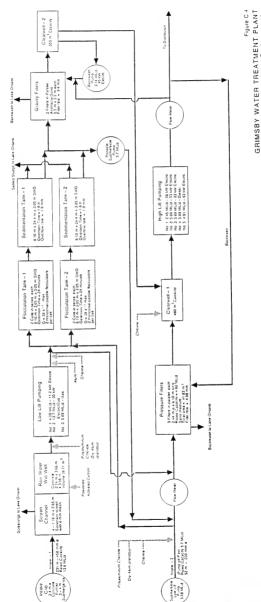
Figure C.4 presents a process design schematic of the Grimsby plant.

## c) Plant Photographs

A photographic record of the plant is included herein following Figure C.4. The record is preceded by a photograph index.







Process Design Schematic



PHOTOGRAPHIC RECORD



# Grimsby W.T.P. - Photograph Index

Photograph	Subject
1	Grimsby Water Treatment Plant - Original Pumping Station Including Pressure Filters
2	Gravity Sedimentation and Filtration Plant - Filter Building and Sedimentation Tanks in Foreground
3	Raw Water Screen and Wall Access to Screen Channel
4	Raw Water Wet Well and Carbon Feeder
5	Polyaluminum Chloride Bulk Storage Tank
б	Polyaluminum Chloride Day Tank and Metering Pumps
7	Dry Alum Feeder
8	Dual Drive Low Lift Pump - Electric/Gas
9	Low Lift Pump Discharge Piping and Raw Water Meter
10	Pressure Filters in Low Lift Pump Room
11	Inlet Channel to Flocculation Tanks
12	Flocculation Tanks
13	Sedimentation Tanks and Covered Overflow Wiers at Discharge
14	Gravity Filters and Filter Console
15	Filter Rate Control Valve in Pipe Gallery
16	Pre-Chlorination System for Pier Pump Discharge
17	Chlorine Room - Pre - and Post Chlorinators with 2-Cylinder Scales
13	Jar Tester
19	Laboratory Counter in High Lift Pump Room
20	High Lift Pump with Diesel Engine Drive
21	High Lift Pump
22	Treated Water Flow Metering Station

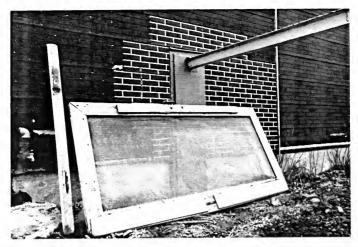




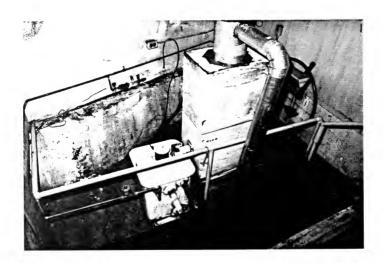
Photograph 1: Grimsby Water Treatment Plant - Original Pumping Station Including Pressure Filters



Photograph 2: Gravity Sedimentation and Filtration Plant - Filter Building and Sedimentation Tanks in Foreground



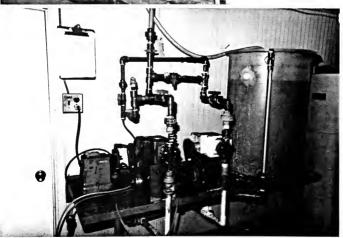
Photograph 3: Raw Water Screen and Wall Access to Screen Channel



Photograph 4: Raw Water Wet Well and Carbon Feeder



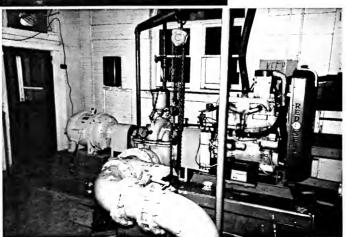
Photograph 5: Polyaluminum Chloride Bulk Storage Tank



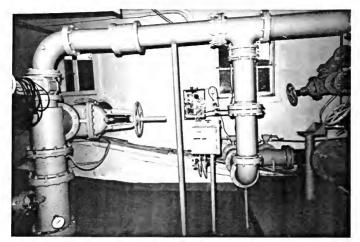
Photograph 6: Polyaluminum Chloride Day Tank and Metering Pumps



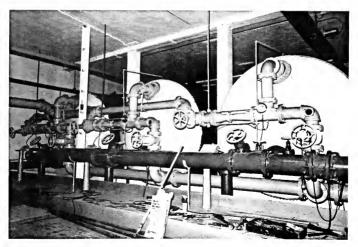
Photograph 7: Dry Alum Feeder



Photograph 8: Dual Drive Low Lift Pump - Electric/Gas



Photograph 9: Low Lift Pump Discharge Piping and Raw Water Meter



Photograph 10: Pressure Filters in Low Lift Pump Room



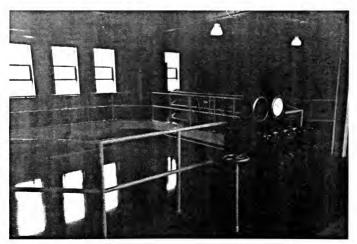
Photograph 11: Inlet Channel to Flocculation Tanks



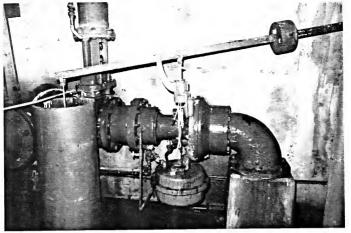
Photograph 12: Flocculation Tanks



Photograph 13: Sedimentation Tanks and Covered Overflow Weirs at Discharge



Photograph 14: Gravity Filters and Filter Console



Photograph 15: Filter Rate Control Valve in Pipe Gallery



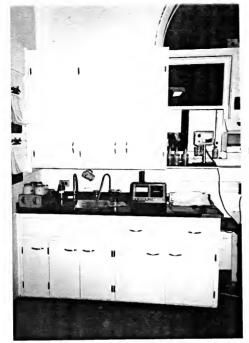
Photograph 16: Pre-Chlorination System for Pier Pump Discharge



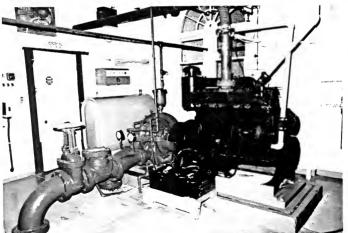
Photograph 17: Chlorine Room - Pre- and Post Chlorinators with 2-Cylinder Scales



Photograph 18: Jar Tester



Photograph 19: Laboratory Counter in High Lift Pump Room



Photograph 20: High Lift Pump with Diesel Engine Drive



Photograph 21: High Lift Pump

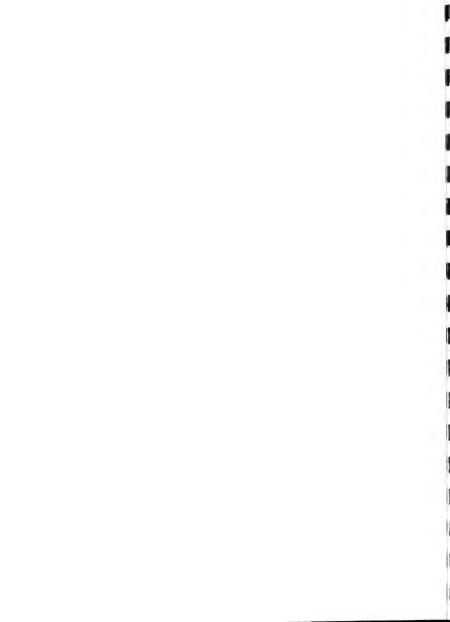


Photograph 22: Treated Water Flow Metering Station



SECTION D

PLANT OPERATIONS



#### D. PLANT OPERATION

### D.1 GENERAL DESCRIPTION

The plant is operated on a manual basis. No analogue supervisory and/or control system exists. All equipment and process operation including the operation of chemical feed systems must be initiated on a manual basis.

Supervisory and operating staff consists of the following:

- Manager, Plant Operations
- Superintendent, Area 3 (Water)
- Foreman, Area 3 (Water)
- Senior Plant Operator
- 3 Plant Operators

Water quality control analyses, described later in Section D.6, and jar tests are performed by the operators at the plant.

The plant operates on the basis of 2-12 hour shifts per day, 7 days per week. One operator is on duty during each shift. During the day shift the operator is supported by the Superintendent and Area Foreman.

The plant operator monitors plant operations, carries out water quality tests, sets chemical feed rates, maintains the daily log sheet, is in charge of receiving chemical deliveries, and backwashes filters.

#### D.2 FLOW CONTROL

## a) Low Lift Pumps

Raw water pumps are selected manually, based on the water level in clear well 1 which is obtained from a level indicator in the low lift pump room. No alarms are provided to indicate high or low level in the clear well.

#### b) Filter Rate Control

The pressure filters at the plant are operated manually, and no control of filter rate is available, other than the limited control provided by partially opening the gate valves on the raw water header piping. Operating staff have no means to monitor the distribution of flow to the three pressure filters, which are operated in parallel.

A self-powered mechanical filter rate controller is provided on each gravity filter discharge pipe. The filter rate is set manually by positioning a counterweight on a graduated weigh beam.

#### c) High Lift Pumps

High lift pumps are selected manually based on pressure in the main discharge header. The operator on duty selects pumps to maintain a discharge pressure of 862 kPa (125 psi). The level in the system reservoir at Park Road is monitored and recorded by a remote circular chart recorder in the plant office. However, the water level is not used for high lift pump control.

## D.3 DISINFECTION PRACTICES

Chlorine gas is used for pre— and postchlorination at the plant. There are three chlorination systems at the plant, one for prechlorination of the pier pump discharge, one for prechlorination of the low lift pump discharge, and one for postchlorination of filtered water. The prechlorination system for the pier pump consists of a Wallace and Tiernan V—notch chlorinator fed by a single gas cylinder. The other two systems consist of Wallace and Tiernan V—notch chlorinators with dual gas cylinders equipped with automatic changeover. All three chlorination systems are interchangeable by means of valving on the chlorine feed piping.

Dosage for pre-chlorinators is set manually. Dosage is selected to maintain a slight free residual in the filtered water. Post-chlorination dosage is also set manually, selected to maintain a total

chlorine residual of 0.3 to 0.4 mg/L in the plant effluent. The points of chlorine application are noted schematically on Figure 0.4 and are listed in Section 0.4.2.

The weight of chlorine used is obtained from the chlorine scales. Dosage is calculated based on the weight of chlorine used and the total treated water flow.

## D.4 OPERATION OF SPECIFIC COMPONENTS

#### D.4.1 INTAKE

As previously described, the plant is served by two intakes, the gravity flow intake and the submersible pier pump intake.

There are no problems with the pier pump intake. Since the intake is only used during the summer, the pump has to be installed at the beginning of each operating season.

No special operating procedures apply to the gravity intake. The intake can be isolated by closing a valve on the inlet pipe in the raw water valve.

Problems, however, are encountered as a result of the location and shallow depth of the gravity intake. It is reported that, when weather conditions are conducive to the formation of frazil ice, the intake must be flushed up to seven times during the night. The shallow depth of the intake also results in rapid variations in raw water turbidity, created by changing wind direction, currents and other factors. Adjacent to the intake to the east is the Forty Mile Creek which discharges to the lake, and raw water quality is adversely affected by the stream during periods of heavy surface runoff. In addition, backwash water and settled sludge from the water treatment plant is discharged to the lake without treatment, not far from the intake. The presence of a sewage pumping station immediately west of the plant could also affect raw water quality due to occasional wet weather overflows.

#### 0.4.2 SCREENING

Photograph 3 illustrates the type of screen that is being used in the Grimsby plant. It will be noticed that screens must be manually removed and washed on the outside of the Screen House. There are no facilities for the collection and disposal of the wash water and the removed screenings.

## D.4.3 LOW LIFT PUMPS

The low lift pumps are started and stopped manually from individual push-button loading stations. No problems were reported, except that the station is limited in flexibility with regard to pump utilization. Pump 2 (13,700  $\rm m^3/d$ ) is the main duty pump (see photograph 8) but is oversized for efficient operation at the average day flow rate. Pump 1 is the only other electric motor driven pump. With a rated capacity of 4,090  $\rm m^3/d$  this pump is now undersized for meeting even minimum day flow rates. Pump 3, at a rated capacity of 5,890  $\rm m^3/d$ , would be more suitable for meeting low flows. Since pump 3 is equipped only with a gasoline engine drive, it is not used very often.

## D.4.4 RAPID MIXING AND FLOCCULATION

There are no formal rapid mixing facilities at the plant. Blending of chemicals with the process flow is achieved hydraulically within the piping systems.

The flocculators are manually started and stopped from a local pushbutton loading station. The rotational speed of the flocculators, which determines the energy input for mixing, is set by adjusting the vari-drive speed switch.

Flocculators are susceptible to significant down-time since they are driven by a single motor. During the winter ice forms on the open-top, outdoor tanks. This can lead to problems when a sedimentation tank

needs to be drained for sludge removal. Also, the efficiency of flocculation is impaired as a result of the extremely cold water temperatures

#### D.4.5 SEDIMENTATION

Sedimentation tanks are gravity flow-through basins. Flow to the basins can be shut off by a plug valve at the inlet channel to the flocculation tanks (photograph 11).

Three weir overflow launders are provided in each tank for decantation of the effluent.

There are no sludge collector mechanisms and tanks have to be cleaned manually by water spray four times per year. Settled sludge and wash water are discharged to the lake via a drain pipe.

Ice formation on the top of the tanks occurs during the winter. This creates problems at the overflow weirs which are partially protected during the winter with wooden covers. The build up of sludge and ice in the sedimentation tanks will also reduce the effective tank volume and impair settling. Desludging of the basins during the winter is not practical and is therefore only undertaken when absolutely necessary.

#### D.4.6 FILTERS

The gravity filters in the Filter Building (photograph 2) are operated manually at a predetermined constant rate of filtration. The filter rate is set manually as described in Section D.2 b) and maintained by a mechanical rate controller (Simplex valve on the filter effluent piping).

The pressure filters are operated manually, and no control of filter rate is available, other than by throttling of gate valves on the raw water inlet piping.

Backwash is initiated manually for all filters, based on either the length of time they have been in operation, in-plant turbidity testing of filtered water, or head loss. No alarms or automatic control are provided for filter backwashing. According to operating staff, the filters in use are backwashed once per day for a 15 minute period when the raw water turbidity is high. The gravity filters have the capacity to operate for longer than 24 hours. However, in winter, operating staff backwash each gravity filter once during the day. The practice is necessary because frazil ice forms frequently over the intake during the night, requiring backflushing of the intake several times. If the gravity filters are backwashed at the same time as the intake is backflushed, there is a risk that production of treated water would not be able to meet demand. The result is that the gravity filters are backwashed more often than necessary.

The filters are returned to service manually when in the opinion of the operator, the filters have been sufficiently backwashed. It is common practice to open the effluent valve slowly over two to three minutes.

### D.4.7 CLEAR WELL

There are two clear water wells, clear well 2 below the gravity filters with a capacity of 355  $\rm m^3$ , and clear well 1 with a capacity of 480  $\rm m^3$  below the pressure filters in the Pumping Station.

Clear well 2 provides the backwash water for the gravity filters and discharges through a 400 m diameter pipe to clear well 1. A manually operated shut-off valve is provided on the discharge header.

Clear well 1 provides detention time for postchlorination and serves as wet well for the high lift pumps.

## 0.4.8 HIGH LIFT PUMPS

High lift pumps are operated manually from the local pushbutton loading stations. Pumps are selected on the basis of system demand which is inferred by the pressure in the discharge main.

### D.5 CHEMICALS

### D.5.1 CONTROL OF CHEMICAL DOSAGES

### a) Coagulant

Until late January 1986, liquid alum was used as the coagulant at the Grimsby plant. In an attempt to improve treated water quality and reduce operating costs, experimentation with polyaluminum chloride (PACl) was commenced. The plant has been operating using polyaluminum chloride as the coagulant since January 27, 1986.

Polyaluminum chloride (or alum) is stored in a PVC lined, wood stave tank and transferred to a smaller day tank as necessary. Two chemical dosage pumps are available for polyaluminum chloride (or alum) feed, a Wallance and Tiernan type A745 diaphragm pump, and a BIF mode: 1210-04 pump. The smaller Wallace and Tiernan pump is used as the duty pump.

The feed rate of each pump is set by manually adjusting the speed and stroke length of the pump. No flow-proportional control of the pumps is available. The pumps have not been calibrated for more than 10 years. The operator checks the amount of coagulant used according to the calibration graph against the amount withdrawn from the day tank. PAC1 is applied at full commercial strength of 33.8 percent.

The operator relies on past trends in selecting an appropriate coagulant dosage. In the past, it has been found that jar test results when used for coagulant control resulted in inadequate treatment. Since total water flow is not metered at the plant, dosage is set approximately, based on treated water flows.

Polyaluminum chloride dosage is calculated by plant staff at every shift using coagulant consumption and total treated water flow. No adjustment of the treated water flow is made to account for in-plant storage (835  $\rm m^3$  max.). The calculation is outlined as follows:

- Litres of polyaluminum chloride used x 407 = grams of polyaluminum chloride
- Grams of polyaluminum\_chloride = mg/L polyaluminum chloride dosage m³ treated water

The factor 407 represents the weight of polyaluminum chloride in grams per litre of solution. The polyaluminum chloride solution is supplied at a concentration of 33.8% (S.G. = 1.204).

Dry alum is used as a standby coagulant. The operator adds a weighed portion of dry alum to a Wallace and Tiernan unit which mixes alum slurry. Dosage is calculated as the weight of alum used divided by the total treated water flow per shift. A second BIF model 1210-4 pump is available to feed alum slurry.

### b) Powdered Activated Carbon

Powdered activated carbon of 400 mesh size is used to control taste and odours. If the operator on duty detects odour (by simply sniffing a sample of the water), dry carbon feed is initiated. A weighed amount of dry carbon is added to the BIF screw type feeder situated over the raw water wet well. The operator sets the dosage at approximately  $1\ \text{mg/L}$ , based on treated water flow, and a more accurate estimation of dosage is calculated later, based on weight of carbon used and total treated water flow.

Carbon feed is stopped when, in the operator's opinion, odour has dissipated. To test for the dissipation of odour, a raw water sample is drawn from the sample tap, heated and smelled by the operator.

# c) <u>Chlorine</u>

As described in Section D.3, chlorine gas in solution form is used for disinfection. Basically, the water flowing through the plant is pre-chlorinated for purposes of disinfection and slime control, and is

postchlorinated for assuring complete disinfection and to maintain a chlorine residual in the water distributed for consumption.

The chlorine dosage is calculated daily based on the weight of chlorine used for each service, obtained from the chlorine scales, and the total treated water flow.

# D.6 SAMPLING AND DATA COLLECTION

# D.6.1 PLANT RECORDS

The plant operator monitors operations and maintains the Daily Record. An example of the Daily Record is included in Appendix A of this report.

Results of chemical and biological analyses carried out at the Ministry of the Environment laboratories are tabulated on summary tables at the engineering office of the Regional Municipality of Niagara.

Information, documented for the three-year operating period for this optimization study, is presented in Appendix C, Tables 1.0 through 7.0 inclusive.

A monthly summary of treated water flows for the last three consecutive years is presented in Table 1.0. This table tabulates monthly daily averages, as well as daily maximum and minimum flows in ML/d.

Daily treated water flows are tabulated in Table 1.1. Separate tables are provided for each year of the three-year record. Flow data presented include monthly daily averages, and daily minimums and maximums. Treated water represents the total daily amount of water pumped into the distribution system.

A particulate removal profile for the plant is presented in Tables 2.0 and 2.1 inclusively. Table 2.1 presents average daily values of turbidity for raw, settled, and treated water as well as average daily

coagulant dosages, and raw water temperature. Table 2.0 presents a yearly summary of maximum, minimum, and average values for the parameters given in Table 2.1 and presents the average monthly raw and treated water  $\mathrm{oH}$ .

The practice of disinfection is covered by Table 3.0, 3.1, and 3.2. Monthly summaries for 1984 to 1986 are given in Table 3.0 and 3.1. These tables present monthly average values for prechlorination and postchlorination dosages, as well as monthly average, maximum and minimum values for the treated water.

A monthly summary of average, maximum and minimum values for carbon for the three year record is given in Table 4.0. Daily carbon dosages for taste and odour control are given in Table 4.1 for 1984 to 1986.

A record of the general chemistry and bacterial water quality is given in Table 5.0. Tests are carried out at the Ministry of Environment laboratories in Toronto and Welland, Ontario, and include:

- general chemical parameters and iron
- bacteria total coliform, total coliform background, fecal coliform and standard plate count.

A three-year summary of raw and treated water quality is presented in Table 5.1. This table includes all the parameters of Table 5.0 but tabulates yearly average, maximum and minimum values.

Algae analyses were not performed on the Grimsby raw water but 3 to 5 samples per month were analysed for chlorophyll  $\underline{a}$  and chlorophyll  $\underline{b}$  at the Ministry of the Environment laboratory in Toronto. Results of these analyses are presented in Table 6.0.

Monthly summaries of the bacteriological test results for 1984 to 1986 are presented in Tables 7.0 and 7.1.

### D.6.2 PROCESS AND QUALITY CONTROL

The plant operator is responsible for maintaining the Daily Record. Data are recorded at various times during the 24-hour day (see Appendix A) and include information on flows, chemical treatment and quality control testing and others. Specific entries of the above form include the following:

### a) Flows

- low and high lift pump operation including elapsed time running hours
- flow meter readings treated water, backwash water, raw water pier numb.

### b) Filter Operation

- time each filter is in service, pressure filters 1, 2 and 3, and gravity filters 4 and 5
- filter backwash operations.

# c) Chemical Treatment

- consumption for each chemical applied in litres or kg
- dosage for each chemical applied, based on actual consumption and feeder setting
- chemical feeder settings, recorded hourly.

# d) Quality Control Testing

The following analyses are carried out at the water treatment plant:

- turbidity six times per day using a Hach, Model

2100A, bench-top turbidity meter for (raw, settled, filtered water effluent and final plant effluent). The low scale on the

meter has a range of 0 to 0.2 NTU.

- odour several times per day (observation only)

- temperature: daily, raw water

- chlorine residual six times per day using a Wallace & Tiernan

series A-790 titrator (free  $\mathrm{Cl}_2$  residual on filtered effluent and free  $\mathrm{Cl}_2$  residual on

final effluent)

- jar tests: as the operator deems necessary to assist

in estimating coagulant dosage, using a

Phipps and Bird jar tester.

### D.6.3 WATER QUALITY EXAMINATION

Water quality analyses for various chemical, biological and bacteriological parameters are carried out routinely at the Ministry of the Environment laboratories. Parameters that have been analyzed for and the frequency of the analyses are as follows:

- bacteriological analyses . at MOE lab

. raw and treated water sampled once per  $% \left\{ 1\right\} =\left\{ 1\right\} =\left$ 

week.

- general chemistry . once per month at MOE lab including:

- test series G + WC51S and FEUT on raw

water:

conductivity, hardness, alkalinity, pH, chloride, turbidity, colour, and iron

- test series G + WC52 + FEUT on treated water: same parameters as above for raw water
- tests series G + LTGLIM on raw water: chlorophyll a and chlorophyll b, 3 to 5 samples per month tested during 1984 and 1985

### D.6.4 LABORATORY EQUIPMENT

The plant has a laboratory counter in the high lift pump room (photograph 19). The basic lab equipment available includes:

- 1 Hach, Model 2100A, bench-top turbidity meter
- 1 Wallace and Tiernan Series A-790 titrator
- 1 Phipps and Bird Jar Test Apparatus

### D.7 PROCESS AUTOMATION

There is no automated equipment at the plant except perhaps for the Wallace and Tiernan chlorinators which include flow-proportional controllers. All pumping and process equipment is coprated on a manual basis. Gravity filters maintain constant rate by mechanically-operated filter rate control valves.

### D.8 DAILY OPERATOR DUTIES

The Superintendent, Area 3 (Water) is responsible for the treatment process and all activities that take place at the plant. He holds a supervisory and staff management position and deals with matters relating to the public. Plant maintenance is the responsibility of the Foreman, Area 3 (Water).

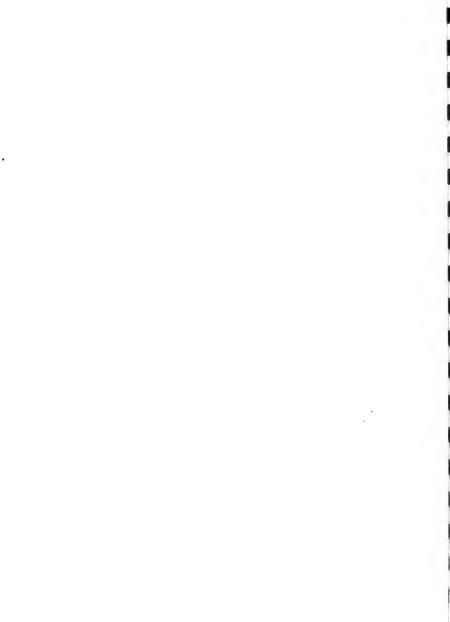
Plant operators are responsible for the day-to-day running of the plant. A partial list of the major duties of the operators includes such activities as:

- keeping records of process operations, chemical treatment and quality control testing,
- checking operation of all equipment and responding to problems when they arise.
- initiating filter backwashing and observing operations,
- responding to and recording treatment upsets, equipment outages, unusual events such as cases of vandalism,
- carrying out water quality control tests and collecting water samples for analysis by outside laboratory,
- setting feed rates of liquid chemical metering equipment and chlorinators.
- receiving chemical deliveries and ensuring adequacy of supplies,
- exercising standby mechanical equipment,
- responding to alarm conditions.

In addition to the physical tasks listed above, operators must stay in constant communication with the Regional Superintendent and Foreman.

SECTION E

PLANT PERFORMANCE



### SECTION E - PLANT PERFORMANCE

### E.1 GENERAL OVERVIEW

Plant operations and performance at the Grimsby Water Treatment Plant were discussed with the Region of Niagara Superintendent, Area 3 (Water), during the site visit on December 16, 1986.

Lake Ontario water is processed by conventional treatment to produce potable drinking water. During the summer, production flows in excess of the capacity of the conventional gravity flow filtration plant are treated by direct filtration in pressure filters. Alum was normally used as the coagulant chemical but during 1986 polyaluminum chloride was used on a trial basis.

Raw water in the vicinity of the intake is subject to wide variations in turbidity during the year. Variations are seasonal and are influenced by the discharge form the nearby Forty Mile Creek.

The operating record reviewed (1984 to 1986) revealed that overall, the treatment process performed well at the hydraulic loadings and solids levels experienced during the study period. On a monthly average basis, filtered water effluent turbidities ranged from 0.10 to 0.56 NTU regardless of which coagulant was used. On a daily basis, higher turbidity values in excess of 1.0 NTU were experienced on several occasions as a result of rapidly fluctuating levels of raw water turbidities. Poor effluent quality was normally contained to one day except for the period of December 27 to 29, 1986, when the effluent turbidity was consistently above 1.0 NTU.

The alum coagulant during 1984 and 1985 was found to work well but higher than normal dosages were required for effective treatment. With polyaluminum chloride, on the other hand, problems were experienced during periods of high raw water turbidities and cold water; hence the use of this coagulant chemical was discontinued in the spring of 1987 in favour of alum.

Unpleasant taste and odours are encountered during the summer months, and on occasions during other times of the year. These odours are effectively controlled by powdered activated carbon treatment.

Disinfection of the raw water is achieved by prechlorination and postchlorination. A good record was established for 1984 to 1986; none of the test samples contained fecal coliform organisms and only one sample in 1986 and two in 1985 tested positive for total coliform.

In summary, therefore, it was concluded that no significant water quality problems exist, either at the plant or in the distribution system. The objectives for water treatment are being achieved in spite of the occurrence of adverse raw water quality, the age of the treatment plant, and operational problems encountered during the wirter as a result of frazil ice in the intake and ice build-up on the surface of the outdoor flocculation and sedimentation tanks. During the winter a quantity problem exists due to partial blockage of the intake by frazil ice.

# E.2 TURBIDITY

# E.2.1 EVALUATION OF PARTICULATE REMOVAL EFFICIENCY

# a) Raw Water Quality

Operating records for particulate removal at the Grimsby Water Treatment Plant are presented in Tables 2.0 and 2.1 of Appendix C. Table 2.0 presents a monthly summary of the average, maximum and minimum raw and treated water turbidity values for 1984 and 1986. In addition, corresponding values are tabulated for i) primary coagulant, ii) raw water temperature and, iii) raw and treated water pH. Average daily values for raw, settled and treated water turbidities, as well as raw water temperature, are recorded in Table 2.1.

In this plant, particulate matter is removed from the raw water by sedimentation and filtration. Polyaluminum chloride (PACI) was used as

the coagulant and is added to the inlet of the raw water suction piping at the raw water well for the main intake or at the pier pump. No. direct mechanical mixing is provided prior to flocculation. Polyaluminum chloride replaced liquid alum as the coagulant on January 27, 1986.

In early 1987, the coagulant application point was changed from the raw water well to the low lift pump discharge header in the Pumping Station.

Lake Ontario water in the region of the Grimsby plant intake, is subject to wide variations in turbidity during the year (Figure E.1). Variations are seasonal and are influenced by i) the shallow and near shore intake location, and ii) the proximity of the intake to the outlet of the Forty Mile Creek. The highest levels of turbidity occur during spring storms when sediment loadings in the creek are high. The highest instantaneous raw water turbidity recorded during the study period on March 29, 1985 was 280 NTU. In addition to high levels, operating staff have reported that turbidity can fluctuate by up to 200 NTU in a 15 minute period which can lead to operational problems at the treatment plant.

Figure E.1 presents monthly raw water turbidity data for 1986 to 1984. Graphs are shown for:

- the monthly average day
- $ext{-}$  the maximum average day of the month
- the minimum average day of the month.

From the figure, it will be evident that the greatest variation in turbidity occurs during the fall to spring period between November and April. During this period maximum day averages range from 15 to 144.8 NTU. As for instantaneous maximum turbidity values, the highest maximum day averages also occur during the spring in February, March and April. The maximum day values recorded for this period are:

139.3 NTU - February 1984, 125.8 NTU - April 1984, 116.2 NTU - March 1985, 144.8 NTU - April 1985, and 69.5 NTU - April 1986. During the summer periods from May to October, maximum day averages for the month vary form 2.5 to 68.0 NTU, while monthly average day values vary from 1.7 to 12.7 NTU.

An analysis of the frequency of occurrence of the monthly average day turbidity levels is given in Table E.1 following. This table was derived from the graph of Figure E.2 and illustrates that the average monthly raw water turbidity is less than 25 NTU for ninety percent of the time, and less than 8 NTU for fifty percent of the time.

Table E.2 presents information on the high raw water turbidity events. The record shows that periods of high turbidity can last for as long as eight day (Mar. 29 - Apr. 5, 1985). Such periods of high turbidity fortunately coincide with lower water demand as illustrated in Figure E.3 which tends to lessen the impact of high solids loadings on settling performance.

# b) Particulate Removal

Particulate removal occurs in two unit processes in the plant, namely the sedimentation tanks and the filters. Until January 26, 1986, liquid alum, or dry alum on an emergency basis, was added to the raw water as the coagulant. On January 27, 1986, the coagulant was changed from alum to polyaluminum Chloride. Coagulant feed rates were adjusted manually by the operators in accordance with changes in raw water turbidity, temperature, and the level of the filtered effluent turbidity.

An alum or polyaluminum chloride (PAC1) dosage guide was not available at the plant; apparently jar tests are carried out as required. Coagulant dosages are set based on experience and treated water effluent quality.

Actual alum dosages applied during the study period are shown graphically as follows:

TABLE E.1

RAW WATER QUALITY - TURBIDITY AND FREQUENCY

1984 to 1986

Turbidity (1)	Frequency per cent time	Total Time Jan. 1984 - Dec. 1986, d
Under 5	31	329
5-10	30	329
10-20	12	131
20-30	21	230
Over 30	6	66
	100	1095

<sup>(1)</sup> Average monthly raw water turbidity

TABLE E.2

HIGH RAW WATER TURBIDITY EVENTS

1984 - 1986

1986	Turbidity (NTU)	1985	Turbidity _(NTU)	1984	Turbidity (NTU)
Apr.5 Apr.6 Apr.17	69.50 40.00 65.70	Jan.1 Jan.2 Jan.3 Jan.4	81.50 78.30 64.70 53.70	Feb.14 Feb.15 Feb.16	82.50 37.60 36.17
Dec.24 Dec.25 Dec.26	24.50 59.70 39.20	Jan.5 Jan.6 Jan.7 Jan.8	61.50 18.30 60.30 72.70	Feb.23 Feb.29 Mar.1	76.16 139.30 44.80
Dec.27 Dec.28 Dec.29	37.27 35.80 52.00	Mar.4 Mar.5 Mar.6 Mar.7	83.80 116.20 76.50 62.50	Mar.28 Mar.29 Mar.30	43.00 66.80 46.80
		Mar.29 Mar.30 Mar.31	88.00 34.20 96.00	Apr.5 Apr.6 Apr.7 Apr.8	125.80 25.80 51.50 35.80
		Apr.1 Apr.2 Apr.3 Apr.4	144.80 126.50 73.30 50.60	Apr.9 Apr.10 Apr.11 Apr.12	38.50 43.80 31.50 35.83
		Apr.5	62.50	Apr.13 Apr.14 Apr.15	31.00 40.33 40.67
		Nov.5 Nov.6 Nov.7	82.30 46.50 46.30	Apr.16	45.20
		Nov.17 Nov.18	56.00 51.00	Dec.22 Dec.23	62.00 42.50
		Nov.28 Nov.29	58.50 38.80		



GRIMSBY W.T.P. STUDY

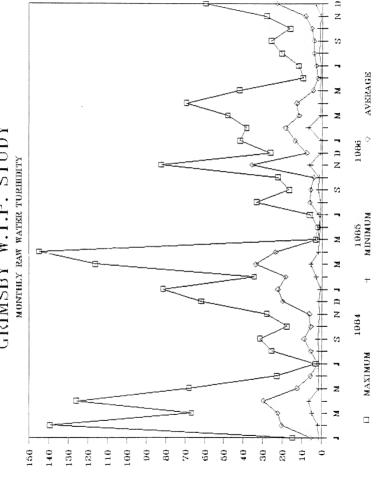
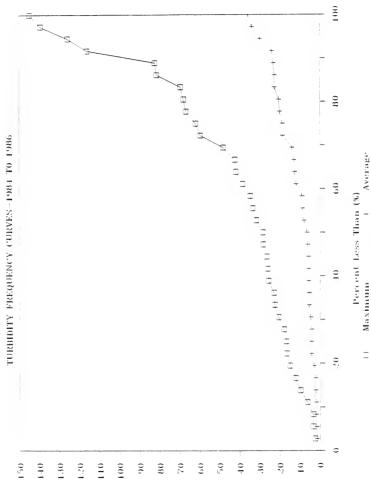


Figure E.1

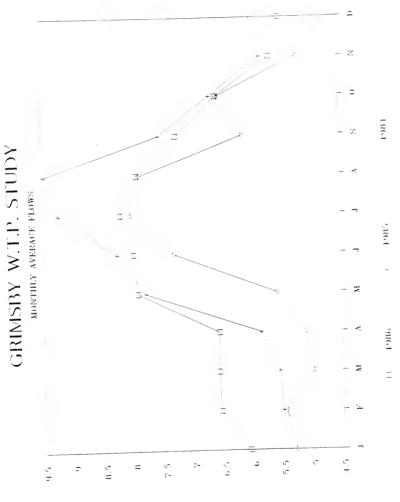
TURBIDITY (FTU)

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Turbidity (FTU)

Figure E.2



Elow (ML/d)



- Figure E.4 Alum Dosage Applied vs. Average Day Raw Water Turbidity for January 1985.
- Figure E.5 Alum Dosage Applied vs. 7-Day Average Raw Water Turbidity for May, June and July 1985.

In addition to the above, maximum day turbidity values versus alum dosages applied were examined for the years 1984 and 1985. The operational record is shown in Table E.3. A summary at the end of the table presents average values for the record as well as the range of low and high values encountered.

Operating data on PAC1 are presented in Figures E.6 and E.7. The former figure presents a dosage graph in terms of 7-day averages for May, June and July 1986, while the graph in Figure E.7 presents the relation of monthly maximum values for the two parameters being considered. PAC1 dosages applied with turbidities in excess of about 40 NTU are summarized in Table E.4.

Performance curves for the sedimentation basins and filters are plotted in Figure E.8. These curves represent monthly average day raw water turbidities versus settled water and filtered water turbidities. Table E.5 presents a summary of turbidity removal and coagulant dosages in terms of monthly average day values.

In reference to Figure E.8 and Table E.5 it is evident that:

- Settling basins perform well at the higher raw water turbidity values for both alum and PAC1 coagulants, efficiencies of removal being over 85 percent in most cases.
- At low raw water turbidities, less than 10 NTU, settling basin performance is much less than at higher turbidities. But this lower performance does not affect filter operation since total solids carried over to the filters are still less than one-half those at high raw water turbidities.

- Filter performance (gravity filters) during the summer period (May to October), and during November when raw water turbidity remains at low levels, is quite good with filtered water effluent turbidities falling in the range of 0.10 to 0.20 NTU. This holds true for 1984 and 1985 when alum was used as the coagulant, as well as for 1986 when polyaluminum chloride was applied.
- During the fall to spring period (November to April) when raw water turbidities fluctuate rapidly with storm events and reach high levels, filter effluent quality deteriorates from that observed during the summer period. With alum as the coagulant, the range in monthly average day filtered water effluent turbidity is from 0.15 to 0.40 NTU (1984 and 1985); while with PAC1 as the coagulant (1986) the range is from 0.18 to 0.56 NTU.
- On a monthly average basis, the turbidity in the filtered water over the study period ranged from 0.10 to 0.56 NTU. The yearly average values for 1984, 1985 and 1986 were 0.22 NTU, 0.19 NTU and 0.23 NTU respectively.
- Based on a consideration of monthly and yearly averages, particulate removal by the treatment plant is good and meets the current drinking water guideline of 1.0 NTU.

Overall water quality goals are being achieved in spite of the age of the treatment facility and the lack of mechanical coagulation equipment. On a day-to-day basis, operating problems during the periods of adverse water quality are more evident and will be examined in the following evaluation.

# Hydraulic Loadings of Process Units

Monthly average, maximum and minimum day flows to the treatment plant during the study period are tabulated in Table 1.0 of Appendix C. Table E.5 summarizes monthly average flows and presents values for the minimum and maximum month of the year. From these records it is evident that the actual flows to the treatment plant ranged from a minimum

TABLE E.3

SUMMARY OF HIGH RAW WATER TURBIDITIES AND
APPLIED ALUM DOSAGES - 1984 AND 1985

Month	Raw Water Turbidity, NTU	Alum Dosage, mg/L
Feb. 1984	139.3	91.6
Mar.	66.8	85.3
Apr.	125.8	106.1
May	68.0	65.4
Dec.	62.0	90.5
Jan. 1985	81.5	87.0
Mar.	116.2	76.0
Apr.	144.8	72.4
Nov.	82.3	85.3
Average	99.3	84
Range	62.0-144.8	65.4-106.1



TABLE E.4

SUMMARY OF HIGH RAW WATER TURBIDITIES AND
APPLIED PAC1 DOSAGES - 1986

Month	Raw Water Turbidity, NTU	PAC1 Dosage, mg/L
Feb. 1986	38.6	13.4
Mar.	48.3	26.1
Apr.	69.5	14.9
May	42.4	23.7
Dec.	59.7	31.9
Average	51.7	22
Range	38.6-69.5	13.4-31.9



IABLE E .5

# SUMMARY OF TURBIDITY REMUVAL AND COAGULANT DOSAGES

rerna

32 13

7. 42

06 87 62 05 64 80 35 70 27 98 24 77 36 56 31 19 23

15 11

(I) Treated water flow.

Мах плия



TABLE E.6

GRIMSBY W.T.P. - HYDRAULIC LOADINGS OF PROCESS UNITS

Unit Loading Rates			
1986 Plant Flows, ML/d			
Yearly Avr.	Max. Day	Min. Day	Design Flow, ML/d (°)
(6.886)	(13.406)	(4.180)	(13.600)
47	24	78	24
5.1	5.1	5.1	5.1
14,500	7,460	23,900	7,350
3.2	1.6	5.2	1.6
0.96	1.88	0.59	1.90
4.74	9.23	2.88	9.37
			4.88(6)
	Yearly Avr. (6.386)  47 5.1 14,500  3.2 0.96	1986 Plant Flows, Yearly Avr. Max. Day (6.386) (13.406)  47 24 5.1 5.1 14,500 7,460  3.2 1.6 0.96 1.88	1986 Plant Flows, ML/d  Yearly Avr. Max. Day Min. Day  (6.886) (13.406) (4.180)  47 24 78 5.1 5.1 5.1 5.1 14,500 7,460 23,900  3.2 1.6 5.2 0.96 1.88 0.59

<sup>(1)</sup> Hydraulically in low lift pumps and raw water piping.

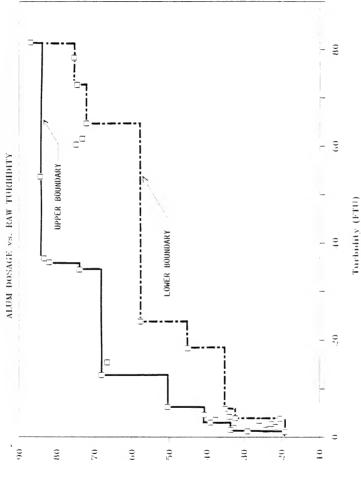
<sup>(2)</sup> At Vari-Drive speed setting of 2.

<sup>(3)</sup> During backwashing filter rate increases by 100%.

<sup>(\*)</sup> Only used during peak summer demand - time in operation not available.

<sup>(5)</sup> Current rated capacity of conventional plant.

<sup>(</sup> $^{5}$ ) At design flow rate of 4,900 m $^{3}$ /d.



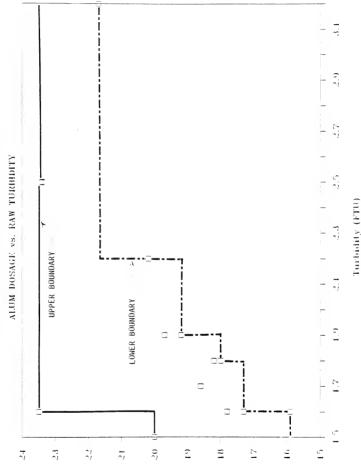
Alum Dosage (mg/L)

NOTE: AVERAGE DAY - JANUARY 1985

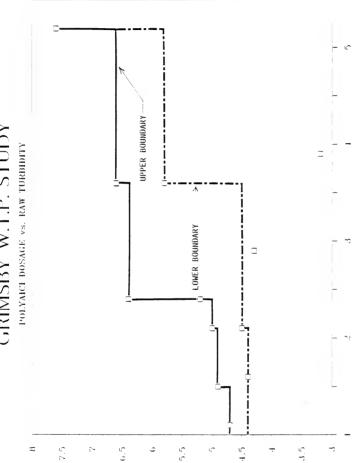
Figure E.4

NOTE: 7 DAY AVERAGES FOR MAY, JUNE AND JULY 1985

# GRIMSBY W.T.P. STUDY



Alum Dosage (mg/L)



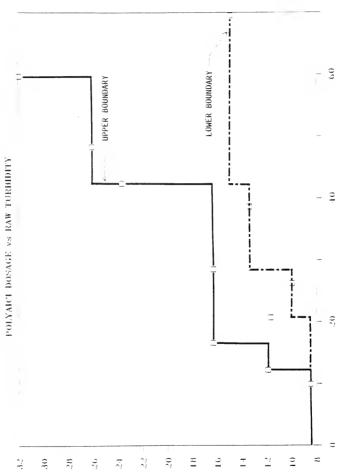
PolyAICI Dosage (mg/L)

NOTE: 7-DAY AVERAGES FOR MAY, JUNE AND JULY 1986

Turbidity (FTU)

Figure E.6

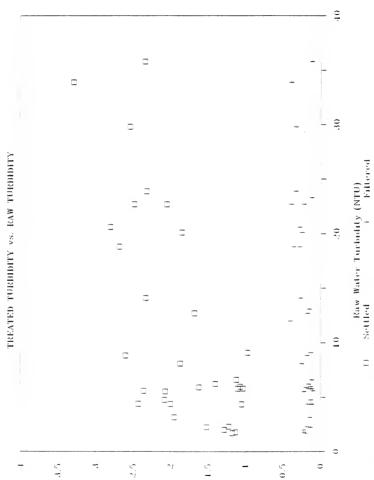




PolyAlci Dosage (mg/L)

Turbidity (FTU) NOTE: MONTHLY MAXIMUM DAY TURBIDITY FOR 1986

GRIMSBY W.T.P. STUDY



Treated Turbidity (FTU)

Figure E.8

average day of 3.441 ML/d set in January 1985 to a maximum average day of 13.555 ML/d set in July 1985. Yearly average flows were 6.034 ML/d, 6.876 ML/d, and 6.886 ML/d for 1984, 1985 and 1986 respectively. Using 1986 flows, corresponding unit process loading rates have been calculated and are compared with design loadings in Table E.6.

Design loading rates for pre-treatment units of flocculation and sedimentation seem to be on the high side — especially for cold water when floc formation is difficult and settling is impaired. The design filter rate of  $9.37\,$  m/h appears to be conservative for dual media filters and is less than the current accepted maximum of  $11.7\,$  m/h. However, operating difficulties at high loading rates have been reported over the years, and in view of the fact that there are only two filters, resulting in 100% overload during the backwashing of one filter, it would appear reasonable to down-size the rated plant capacity to about one-half the current rating, or  $6.800\,$  m³/d, which is the design capacity of the original single layer sand filters constructed during the plant expansion in  $1957.\,$  At  $6.800\,$  m³/d, loading rates for flocculation and sedimentation basins also are more appropriate (see Table E.6 for yearly average flow), and approach generally recommended design values in case of a difficulty to treat water.

Based on the above discussion, it can be concluded that the Grimsby W.T.P. (gravity flow section) is overloaded almost all the time. During 1986 average day water production approached the original design capacity of  $6,800~\text{m}^3/\text{d}$  during November, December, and January to April; during all other months of the year this capacity was exceeded. This situation will explain the use of the pressure filters with a design capacity of  $4,900~\text{m}^3/\text{d}$  at a design loading rate of 4.38~m/h. With the additional capacity of the pressure filters, the total plant filtration capacity is  $11,700~\text{m}^3/\text{d}$ . This capacity however is only available during periods when raw water turbidity is low (May to October) since pressure filters are operated in the direct filtration mode with raw water supplied by the pier pump. In this regard, the pressure filters are valuable and are used primarily to help treat maximum day summer flows. On occasions, when the pier pump is drawing turbid water, or

when the gravity filters appear overloaded, settled water can be pumped back to feed the pressure filters (see Figure C.3).

### Plant Performance With High Raw Water Turbidity

Table E.7 presents plant operating data for periods with high raw water turbidity. Data selection was based on:

- high (or above normal) raw water turbidities;
- poor performance of settling basins as evident by high settled water turbidity;
- filtered water effluent turbidity higher than normal and when the drinking water objective of 1.0 NTU was exceeded;
- the use of unusually high alum or PAC1 coagulant dosages.

By examining the data in Table E.7 for alum coagulation (1984 to January 26, 1986), it will be noticed that:

- Settling basin performance generally was quite good with the exception of March 29, 1985 when the average settled water turbidity for the day was 19.5 NTU.
- Treated water turbidity on the other hand, in spite of low settled water turbidities, generally was on the high side and exceeded the objective of 1.0 NTU many times. A maximum treated water turbidity of 3.4 NTU as recorded for March 29, 1985. When PACI was used as the coagulant, a maximum treated water turbidity of 10.6 NTU was recorded for December 27, 1986.
- The poor filter performance occurred with only moderately high levels of raw water turbidity and flows well below the design capacity of 6,300 m<sup>3</sup>/d.

It is suggested that some of the reasons for the poor performance may be attributed to:

- the cold raw water temperature combined with high turbidity which

#### TABLE E.7

#### PLANT PERFORMANCE DURING PERIODS OF

# HIGH RAW WATER TURBIDITY - 1984 to 1986

		HIGH	KAW WATER	TURBIULIT	- 1984 10	1986	
Dat 198	t e 36	Average <u>Raw</u>	Day Turb Settled	dity, NTU Treated	Alum mg/L	PAC1 mg/L	Flow ML/d
Jan.	19 20 21 22 23 24 25 26 27 28	12.6 22.6 21.3 18.3 9.8 10.4 22.0 21.3 35.7 12.9	2.9 1.6 2.9 3.9 2.7 2.7 3.0 4.6 2.9	0.24 0.17 0.45 0.47 0.28 0.41 0.45 0.51 0.60	49.7 46.6 47.9 62.9 89.9 48.5 54.6 32.3	14.9 16.2	5.873 6.156 6.094 6.030 6.415 5.947 5.884 5.737 6.316
Apr.	17 18	65.7 10.1	23.7	9.54 0.59		14.9 11.9	5.918 7.304
Мау	19 20 21	30.4 42.4 3.0	1.2 10.3 3.3	1.42 2.50 0.22		3.4 23.7 12.6	6.545 6.024 7.127
No∨.	26 27 28	21.0 27.4 8.8	5.4 3.4 6.5	0.41 0.99 0.10		16.0 8.5 16.1	5.254 5.481 5.681
Dec.	27 28 29 30 31	37.3 35.8 52.0 31.7 37.5		10.64 1.02 1.31 0.22 0.11		29.5 22.2 21.1 31.9 17.5	4.180 6.105 4.985 4.383 6.596
191	85						
Jan.	10 11 12 13	36.8 36.0 23.8 12.8	3.1 4.7 2.6 2.0	0.97 1.60 0.32 1.03	83.4 82.0 57.7 68.1		4.050 4.296 4.571 3.746
Feb.	4 5 6 7 8 9	83.8 116.2 76.5 62.5 39.8 35.2 35.3	3.3 5.5 4.9 3.8 4.1 3.8	0.24 0.31 0.64 1.03 0.61 0.80 0.56	59.7 76.0 64.0 65.6 62.1 67.3 65.3		5.992 5.484 5.182 5.644 5.784 5.569 5.305
Mar.	28 29 30	18.5 88.0 34.2	1.9 19.5 2.1	0.14 3.4 0.12	43.8 66.8 52.5		5.325 4.880 6.233
Nov.	5 6 7	82.3 46.5 46.3	1.2 1.5 1.9	0.14 1.82 0.17	59.4 61.0 35.3		5.308 5.631 5.388
19	84						
Feb.	27 28 29	8.1 78.2 139.3	1.5 2.5 4.2	0.21 0.27 0.15	41.7 75.9 75.0		5.796 4.591 4.959
Mar.	1 2 3 4	44.8 14.6 13.8 12.7	3.5 2.1 2.3 2.3	1.10 0.45 0.43 0.43	81.0 64.4 50.9 47.8		5.092 4.796 4.855 4.509
Apr.	4 5 6 7 8 9 10 11 12	24.5 125.8 25.5 35.5 38.5 43.8 31.5 35.8	2.1 9.57 4.6 3.7 4.5 2.9 3.7	0.18 0.55 0.63 0.98 0.30 1.97 0.26 0.23	55.5 83.5 77.2 103.1 89.0 106.1 77.4 75.2 88.0		4.751 4.619 4.596 4.387 4.696 5.105 5.514 4.869 4.878

- poor coagulation:
- insufficient flocculation;
- the unusually high alum dosage applied which may be due to the lack of adequate rapid mixing and insufficient flocculation.

It appears that the high alum dosage is required to maintain a low settled water turbidity as well as for maintaining the desired filtered effluent quality. Unfortunately, alum produces a weak floc which will break through the filters as the shearing forces increase with increasing head loss and/or filter rate.

A second problem with the high alum dosages relates to the large voluminous floc that is produced which, if carried over to the filters even in only small quantities, will result in significantly shorter filter runs.

Shortened filter runs require more frequent backwashing which will impact significantly on the net water production capacity of the plant. Plant staff indicated that with poor raw water quality filters are backwashed at least once during a 24-hour period. For a 10-minute backwash and surface rinse, about 250  $\rm m^3$  of water are required at the design backwash rate for cleaning of one filter. For two filters in a 24-hour period, this amount to 500  $\rm m^3/d$  or about 8.5% of the net amount of water produced on April 17, 1986. Since clear well 2 only has a capacity of 355  $\rm m^3$ , problems may be encountered with the operation of the filters.

During 1986, with polyaluminum chloride as the coagulant, the problem of poor filtered effluent quality experienced during periods when raw water turbidity was high may be attributed to under dosing rather than overdosing. However, overdosing with PAC1 also occurred but generally only following the correction of an under dose.

## c) Treatability Tests

Jar tests were performed on Grimsby W.T.P. raw water taken on April 24, 1987 when raw water turbidity was relatively high (30 to 40 NTU).

These tests were carried out to establish the optimum coagulant dosages for liquid alum and polyaluminum chloride as well as to compare the performance of the two coagulant chemicals in terms of: optimum dosage, time to visibility of first floc, floc appearance, floc size and quantity, settling velocity, and turbidity of filtrate form a laboratory filter paper.

Five jar tests were done in total, two with alum and two with PACl, and one with alum and PACl at previously determined optimum dosages. Test procedures and results obtained are presented in Appendix B. Results for settled water turbidity were plotted in terms of settling velocity distribution curves for each test. Settling velocities measured ranged from 0.465 cm/min. (138 Igpm/sf) to 6.00 cm/min. (1800 Igpm/sf).

For Test 1, the raw water turbidity was  $31.1~\rm NTU$ , the temperature  $10^{\circ}\rm C$ , and the pH 7.95. Apparent colour was measured at  $25~\rm Hazen~umits$ . The optimum alum dosage is probably somewhere between  $16~\rm and~24~mg/L$ ; however, based on filtered effluent quality, settling performance, and the objective for minimum chemical consumption,  $16~\rm mg/L$  could be considered adequate. The maximum settling velocity measured was  $3.33~\rm cm/min$ . at which rate the settled water turbidity was  $3.0~\rm NTU$ . This settling velocity is equivalent to  $2.0~\rm m/h~(1000~\rm Igpd/sf)$ . In full-scale design this rate should translate to a maximum value of  $1.0~\rm m/h~(500~\rm Igpd/sf)$ . The filtrate turbidity of  $0.06~\rm NTU$  is indicative of good coagulation leading to a high quality effluent in full-scale treatment.

For Test 2 raw water quality was similar to that of Test No. 1. Almost identical results were achieved with alum dosages of 14 and 16 mg/L and 14 mg/L alum could be considered the optimum dosage. At this stage, the maximum settling velocity was measured at 3.75 cm/min. and the corresponding settled water turbidity was 2.7 NTU. For design, this settling velocity would translate to a maximum of 1.12 m/h  $(560~{\rm Igpd/sf})$  which is similar to that obtained in Test 1.

The design settling rates determined from Tests 1 and 2 are similar in magnitude to the actual design overflow rate of 0.95 m/h (475 Iqpd/sf)

and confirm that the actual design capacity of the gravity section of the treatment plant is  $6,800 \text{ m}^3/d$ .

Jar Test 3 was carried out with PACl as the coagulant. Raw water characteristics were: turbidity 40.1 NTU, colour 25 apparent Hazen units, temperature  $10^{\circ}\text{C}$ , and pH 7.98 units. PACl dosages of 2 to 24 mg/L were applied in the test and 8 mg/L appeared to be the optimum dosage for treatment. A lower dosage of 4 mg/L also gave satisfactory results after filtration but settled water turbidity at 5.5 NTU was high at the maximum measured settling velocity of 3.33 cm/min.

For Test 4 raw water turbidity was 30.4 NTU with other parameters being similar to those in Test 3. Again PAC1 was the coagulant and dosages of 4 to 16 mg/L were applied. The optimum dosage could be considered as falling between 6 mg/L and 8 mg/L PAC1.

Even at 6 mg/L excellent settled water clarity (1.96 NTU turbidity) was achieved at a settling velocity of 3.33 cm/min. which would translate to a design rate of 1.0 m/h (500 Igpd/sf). A good filter effluent quality was achieved with all PAC1 dosages applied in Test 4. This leads to the conclusion that good filter performance also should be achievable at the optimum PAC1 dosage in full-scale treatment (providing filters meet acceptable design standards).

A comparison of the performance of the two coagulants was carried out in Test 5. Dosages were selected on the basis of optimum dosages established for each coagulant in previous tests. Again, raw water characteristics were similar to those for previous tests, the turbidity being 35.7 NTU. Alum dosages used in the trial were 14, 16 and 18 mg/L while PAC1 dosages were 7, 8 and 9 mg/L. The optimum alum dosage in this trial could be considered as 16 mg/L. At this dosage and a settling velocity of 3.75 cm/min., the settled water turbidity was 2.6 NTU. Filtration of the settled water produced a filter effluent turbidity of 0.09 NTU.

The test results for PAC1 in Test 5 indicate an optimum dosage of 7 mg/L and maximum settling velocity of 3.33 cm/min. At this velocity

the settled water turbidity was 1.68 NTu which is somewhat better than the corresponding turbidity for alum coagulation. Filtrate effluent quality at 0.10 NTU turbidity was similar to that obtained with alum.

Conclusions that may be drawn form the jar test trials are as follows:

1. The optimum alum dosage is about 16 mg/L for a raw water turbidity of 30 to 40 NTU, temperature of  $10^{\circ}\text{C}$ , and pH of 7.95 units.

The corresponding polyaluminum chloride dosage for similar water quality is about  $7\ \text{mg/L}$ .

- Maximum settling velocities in the jars resulting in acceptable water quality were established as 3.75 cm/min. for alum and 3.33 cm/min. for PACI. These rates are fairly similar and, based on the latter, would translate to a maximum full-scale design rate of 1.0 m/h (500 Iqpd/sf).
- Although laboratory filter test results do not allow prediction of plant filter design parameters, the results show that good filter performance can be expected at the optimum alum and PAC1 dosages with a well designed filter.

# d) Capability of Existing Plant

The combined rated capacity of the existing Grimsby W.T.P. is  $19,300 \, \text{m}^3/\text{d}$ . The gravity filtration plant has a rated capacity of  $13,600 \, \text{m}^3/\text{d}$ , and the pressure filtration plant has a rated capacity of  $5,700 \, \text{m}^3/\text{d}$ . Average daily flows for  $1985 \, \text{and} \, 1986$  were about  $6,900 \, \text{m}^3/\text{d}$  and the  $1984 \, \text{average}$  was about  $6,000 \, \text{m}^3/\text{d}$ .

The highest daily flow during the three-year study period was  $14,026~\rm{m}^3/d$ . This represents only 73% of the combined rated capacity of the plant and about 103% of the rated capacity of the gravity filtration plant. On this day, Friday August 2, 1985, the average raw water turbidity was 3.90 NTU, settled water turbidity 1.9 NTU and treated water turbidity 0.14 NTU.

It is doubtful whether plant operations could have been maintained on August 2, 1985 with higher raw water turbidities or without the use of the pressure filters. During the winter period with poor raw water quality and icing conditions existing on the sedimenation basins, operating difficulties with the gravity filtration plant are to be anticipated with flows reaching the design capacity of  $6.800 \, \text{m}^3/\text{d}$ .

#### E.2.2 OPTIMUM PERFORMANCE ALTERNATIVES

As is evident from the existing operational record, reviewed in Section E.2.1 a) above, that the Grimsby W.T.P. has difficulty in consistently meeting the treated water objective for turbidity of less than 1.0 NTU. In 1986, there were 15 days with average daily treated water turbidities of 0.5 NTU and greater, with 6 of these greater than 1.0 NTU and one greater than 10.0 NTU. In 1985, there were 16 days with average daily treated water turbidities of 0.5 NTU or greater, with 5 of these greater than 1.0 NTU. In 1984, there were 13 days with turbidities of 0.5 NTU or greater, with two of these greater than 1.0 NTU.

Several proposals were evaluated for improving treatment performance. The options considered most feasible are presented below in order of priority.

## Option 1 - Monitoring and Control of Coagulant Dosage

Wide fluctuations in raw water quality, as reported by the plant staff, could have a significant impact on the ability of the plant to produce acceptable treated water quality on a consistent basis. Automatic control of coagulant dosing would have the beneficial effect of providing for optimum coagulant dosing through a wide range of raw water turbidity.

The current method of chemical dosing involves manually setting the dosage and making adjustments as required. But as shown in the records (Table 2.1, Appendix C) it may not be possible to respond to dramatic changes in raw water turbidity. For example, on May 19, 1986, there

was a sudden change in raw turbidity from 1.20 NTU the previous day, to 30.43 NTU. Because of the lag in coagulant dosage change, the treated water turbidity jumped from 0.17 to 1.42 NTU. Once an appropriate dosage was used, the turbidity was restored to an acceptable 0.22 NTU. It is likely that automatic control of caogulant dosing could have avoided this high treated water turbidity since the flows were below average and only the high raw water turbidity appears to have contributed to the high treated water turbidity.

The Streaming Current Detector (S.C.D.) is a continuous sampling, online instrument for monitoring the optimum coagulant dosage relative to a predetermined set-point. The S.C.D. output signal can be continuously recorded and is available for activating high/low alarms and for coagulant feed control. The instrument will indicate coagulant over-dosing and under-dosing and is claimed to be the best instrument currently available for control of the coagulation process.

This option would require a fully equipped S.C.D., new chemical feed pumps with automatic speed and stroke adjustments, and a raw water flow meter and controller.

# Option 2 - Rapid or Flash Mixing

At the Grimsby W.T.P. rapid mixing of alum or polyaluminum chloride occurs in the raw water piping between the low lift pumps and the floculation tanks. Adequate chemical dispersion is not achieved with this type of mixing which must rely on turbulence in the piping and raw water pumps.

The efficiency of coagulation can be improved by the installation of in-line, rapid mixers for each treatment train (gravity plant and pressure filters). The alternative to in-line mixers would be a flash mixer consisting of a pipe injector (or turbine in an open channel). These latter units provide a high degree of mixing at a fraction of a second which is essential for the most efficient use of the coagulant in coagulation.

#### Option 3 - Flocculant Aid

This option is closely related to Options 1 and 2 above and attempts to improve settling basin performance by the addition of a cationic polyelectrolyte as a flocculation aid.

Consideration should be given to the addition of a cationic polyelect-rolyte following coagulation to serve as a flocculation aid. This treatment might reduce the high coagulant dosage required to treat raw water during troublesome periods. The effectiveness of polymer addition should be established through jar tests. Potential benefits may include improved filter performance with respect to both quality and the length of filter runs, and lower overall chemical costs.

#### Option 4 - Filter Capacity

It appears that filter capacity has limited plant operations during the winter period, probably more so than sedimentation basin capacity which can be manipulated to some degree by the use of a flocculation aid.

Additional filter capacity during the winter is available in the form of the existing pressure filters, providing they can be operated in parallel with the gravity filters on water from the settling basins. Investigations should be carried out to establish feasibility of this proposal and to determine what piping and pumping changes are required to bring the pressure filters into service during the winter.

## Option 5 - Pressure Filters

The available filter area consists of  $60.5~\text{m}^2$  of gravity filters and  $42.0~\text{m}^2$  of pressure filters. The pressure filters are used during peak summer demands when raw water turbidity is low, and normally in the direct filtration mode. When raw water turbidity exceeds 20 NTU, the pressure filters can be used in conjunction with the sedimentation tanks.

During normal operation of the pressure filters, coagulant (PAC1 or alum) is added to the raw water discharge pipe at the pier pump. No

mechanical rapid mix or flocculation facilities exist. Some mixing occurs in the piping to the pressure filters and flocculation may occur in the filter media. Nevertheless, the coagulation and flocculation of colloidal turbidity may be incomplete. Furthermore, raw water turbidity at the pier pump inlet is not monitored on a rigorous basis and the coagulant chemical dosage is manually set with little adjustment for variations in turbidity. For these reasons the effluent quality may not be as good as that from the gravity filters. Better overall performance may be achieved by passing all raw water flows through the pretreatment units (flocculation and sedimentation basins) prior to filtration. This hypothesis should be confirmed through full-scale plant trails.

#### Option 6 - Filter Operation

#### 1) Filter Rest Period

Improvement in overall treated water turbidity may be possible by improving operations of the filters.

The objective is to reduce or eliminate the initial filter breakthrough which occurs immediately following filter backwashing. This can be achieved, in part, by letting a filter rest for about 15 minutes after a wash before returning the filter to service. The assumption is that during the rest period the filter media will compact and return to conditions similar to those prior to backwashing. If this is so , then the filter should produce water with low turbidity immediately following start-up.

Allowing a filter to rest after backwashing would be simple to implement at virtually no cost. What needs to be established is whether the duty filter(s) will be able to sustain the additional hydraulic load without deterioration in effluent quality for the extended time that the filter being washed is out of service.

### 2) Hydraulic Surges

Initial high turbidity in the filter effluent can also be caused by hydraulic flow surges. The existing practice of slowly opening the filter effluent valve over two to three minutes should minimize this problem and the practice should be continued.

### 3) Filter Conditioning

An alternative method for reducing the initial filter breakthrough after a wash cycle is to condition the filter media using alum or a polymer. The coagulant would be applied to the wash water near the end of the backwash cycle. As an example, this procedure of filter conditioning is currently being used at the Toronto Island Filtration Plant with some degree of success.

Implementation of this alternative will require the provision of an alum or polymer feed system capable of applying up to 5 mg/L of alum or 3 mg/L of a non-ionic polymer to the filter backwash water.

# 4) Filter to Drain

A third alternative for reducing initial filter breakthrough after start-up is to filter to drain. Although simple in concept, this alternative would be difficult to implement at the Grimsby W.T.P. Filter effluent piping would require the addition of filter to drain piping equipped with automatically controlled valves.

As for Option 6 (1), this option would increase the time a filter being backwashed is out of service which may affect effluent quality from the duty filter. In addition, the was water consumption could increase by up to 50 percent over the existing rate.

# 5) Duration of Filter Backwash

This option is aimed at reducing the amount of filter backwash water used by stopping the wash water cycle automatically based on a pre-

determined level of turbidity in the wash water. The Hach Company is now marketing a backwash water turbidity meter specially designed for measuring the high turbidities in the wash water.

#### E.3 DISINFECTION

#### E.3.1 PROCESS EVALUATION

#### a) Chlorination Equipment

The plant includes a separate gaseous chemical room equipped with the following storage and feed facilities:

- three Wallace and Tiernan V-notch gas chlorinators; one for prechlorination at the pier pump discharge, one for postchlorination of the low lift pump discharge, and one for postchlorination of the filtered water.
- one standby chlorinator which has been disconnected,
- 3 2 cylinder scales by Wallace and Tiernan,
- 7 68 kg chlorine cylinders, 5 in service, 2 spare, 7 empty.

# b) Application Points

Chlorine solution is applied to the pier pump discharge and the main low lift pump discharge for prechlorination. Postchlorination involves application of chlorine solution to the inlet of clear well 1 in the Pumping Station.

## c) <u>Dosages and Control</u>

A record of the disinfection practice at the plant is provided in Tables 3.0, 3.1, 3.2, 5.0 and 5.1 of Appendix C. Table E.8 presents a three year summary of chlorine dosages applied and resultant chlorine residuals. Annual average prechlorination dosages were from 1.40 to 1.58 mg/L and the postchlorination dosages from 0.21 to 0.25 mg/L. Applied dosages reflect the chlorine demand which is relatively constant, but slightly higher in summer and early fall.

TABLE E.3

CHLORINATION - 3-YEAR SUMMARY

	1986	1985	1984	
Parameter	Max. Min. Avg.	Max. Min. Avg.	Max. Min. Avg.	
Pre-chlorination				
- chlorine dosage	1.40	1.55	1.58	
- free chlorine residual	0.24 0.08 0.14	0.28 0.12 0.19	0.25 0.11 0.17	
Postchlorination				
- chlorine dosage	0.21	0.23	0.25	
- total chlorine residual	0.66 0.29 0.38	0.51 0.32 0.42	0.54 0.19 0.41	

Units in mg/1.

Dosage for pre- and postchlorination are set manually with the objective of maintaining a total chlorine residual in the treated water of 0.3 to 0.4 mg/L.

#### d) Chlorine Residuals

For prechlorination, the free chlorine residual is monitored on filtered water. During the study period, the average free chlorine residual was 0.17 mg/L with a range from 0.08 to 0.28 mg/L.

The total chlorine residual, after postchlorination, is measured manually six times per day. The average annual total chlorine residual varied from 0.38 to 0.42 mg/L; while the range for the three year period was from 0.19 to 0.66 mg/L.

#### e) Process Evaluation

Pre- and postchlorination dosages are selected to meet the plant's objective of maintaining 0.3 to 0.4 mg/L of total chlorine residual in the treated water. The prechlorination dosage is applied prior to flocculation and sedimentation but after the low lift pumps.

In addition to disinfection of the water, precholorination at the treatment plant is often necessary to achieve additional objectives including:

- control of taste and odours;
- inactivation and prevention of the growth of algae and bacteria in pretreatment units and in the filter media;
- preventing slimes from developing on the filters;
- oxidation of chemical constituents.

Unfortunately, prechlorination increases the potential for the formation of trihalomethanes (THMs). Since no data for the existing levels of THMs in the finished water were available, no direct comments regarding this potential problem can be made. However, since THMs

levels at other Great Lakes areas are in the order of 30  $\mu$ g/L (350  $\mu$ g/L being the current Drinking Water Objective), it can be assumed that the levels at Grimsby also are low. Nevertheless, it is suggested that tests be carried out to establish the level of THMs in the finished water from the Grimsby plant.

The clear water wells have a total volume of 835 m<sup>3</sup>: 480 m<sup>3</sup> associated with the pressure filtration plant - clear well 1, and 355 m<sup>3</sup> with the gravity filtration plant - clear well 2. The normal operation of the plant provides for series operation of the clear wells, with postchlorination in clear well 1 (below pressure filters). Chlorine solution is added to the inlet pipe and can also be added to the bottom of the clear well below the inlet pipe form clear well 2. Clear well 1 also serves as the high lift pumping station wet well. The chlorine contact time, therefore, varies with the water level in the well. At the maximum high lift pumping rate of  $13,700 \text{ m}^3/\text{d}$  (3 electric pumps operating) and high water level in the well, the detention time, assuming complete mixing, would be about 50 minutes. At low water level the detention time would be as low as about 16 minutes. In addition to the variable chlorine contact time, uniform mixing may not be achieved since high lift pump suction headers are spaced along the south wall of the well at right angles to the inlet and point of chlorine addition.

The record for bacterial water quality, both raw and treated, has been compiled in Tables  $5.0,\ 5.1,\ 7.0$  and 7.1 of Appendix C.

Data indicate that, of 142 raw water samples analysed for total coliform content during the three-year study period, 69% contained 1-100 coliforms per 100 mL, 28% contained 101-5000 coliforms per 100 mL and 3% contained more than 5000 coliforms per 100 mL. Of 143 raw water samples analysed for fecal coliform content, 74% contained 0-10 organisms per 100 mL, 25% contained 11-500 organisms and 1% contained more than 500 fecal coliform organisms. Of 114 raw water samples analysed for fecal streptococcus, 43% contained 0-1 organisms, 49% contained 2-50 organisms and 3% contained more than 50 organisms. The

highest total coliform background counts occurred in July or August each year, while higher total coliform and fecal coliform counts generally occurred in late spring and/or late fall.

Treated water data for the three-year study period indicate an absence of coliform organisms in all tests except two tests carried out in December 1985, when total coliform content was analysed to be less than 2 organisms per 100 mL, and one test carried out in September 1986, when a presumptive test was positive.

Test results showed 18 positive tests for total coliform background in treated water. The range for 14 of these positive tests was 1-10 organisms/100 mL. The highest test value recorded was 90,000/100 mL, in June. 1984.

Standard plate count data for treated water indicated the majority of tests in the range of 0--100 organisms per mL. Three tests in the three year study period showed more than 2400 organisms per mL. These were samples taken during June or July of each year.

A summary of the bacteriological data for the study period is presented in Table E.9. These data indicate an acceptable record for disinfection at the plant. During the study period, only one test for total coliform organisms was positive in 1986 and two in 1985.

The efficiency of disinfection is primarily dependent upon the available concentration of free chlorine and contact time. The former is pH dependent since chlorine in water hydrolyzes to form hypochlorous acid which dissociates and is in equilibrium with the hypochlorite ion. As pH increases, the hypochlorous acid concentration decreases, but increases slightly with cold water. At pH greater than 3.0, the hypochlorous acid concentration varies between 22% at 20°C to 30% at 0°C. At pH of 7.5, concentrations are 47% at 20°C and 58% at 0°C. Since the hypochlorite ion has virtually no disinfection capability, it is clear that the efficiency of disinfection can be improved for a given dosage of chlorine by operating at a raw water pH of about 7.5 rather than 3.0 or above.

The raw water at the Grimsby plant has an average pH of 8.3, with a range from 7.9 to 8.6. Generally, the pH is slightly higher in summer than during the rest of the year. The addition of chlorine and alum reduces the pH during treatment by about 0.6 pH units (1984 ad 1985). Chlorine and polyaluminum chlorine reduces the pH by about 0.2 pH units. Therefore, a disadvantage of the use of polyaluminum chloride compared to alum would be its inability to reduce pH in the treated water by as much as for alum resulting in a higher pH and therefore decreased disinfection efficiency. This is particularly important for the Grimsby situation because the pH of the raw water is already greater than 8.0.

Based on the theory of chlorination, it should be possible to improve chlorination efficiency by lowering raw water pH. This can be achieved by adding acid or, with alum as the coagulant, by using acidified alum. The former approach is more complicated and involves using a hazardous chemical. The use of acidified alum would not change existing operations and should be investigated as a feasible alternative to improve disinfection.

Chlorine contact time and mixing can e improved by adding a second postchlorination point to the effluent from the gravity filters at the inlet to clear well 2.

## E.3.2 CAPABILITY OF EXISTING PLANT

The existing chlorination facilities and procedures appear to be sufficient for the production of water that is bacteriologically safe.

# E.3.3 OPTIMUM DISINFECTION PROCEDURES

Having thoroughly reviewed the current chlorination practice, the following is recommended:

1) TTHM data on treated water should be obtained;

TABLE E.9

BACTERIAL WATER QUALITY - 3-YEAR SUMMARY

	19	86	19	85	19	84
	No. of Samples	% Total Samples	No. of Samples	% Total Samples	No. of Samples	% Total Samples
RAW WATER						
Total Coliform .						
0-100/100 mL	34	69.4	30	62.5	35	71.4
101-5000/100 mL	14	28.6	17	35.4	12	24.5
≥ 500/100mL	1	2.0	1	2.1	2	4.1
Fecal Coliform						
0-10 mL	38	79.2	35	70	35	71.4
11-500/mL	10	20.8	14	28	13	26.5
≥ 500/mL	-	-	1	2	1	2.1
TREATED WATER						
Present/Absent Test						
Total Coliform A	29	93.5	-	-	-	-
Р	2	6.5	-	-	-	
TC Positive						
0-4/100 mL	1	-	-	-	-	-
MF Test						
Total Coliform						
Absent	24	100	46	95.8	48	100
1-4/100 mL	-	-	2	4.2	-	-



- Methods for reducing the finished water pH to about 7.5 should be investigated;
- 3) In addition to the existing application point, the benefits of chlorinating the gravity filter effluent as it enters clear well 2 should be investigated.

The process changes recommended for further study could be tested on a temporary basis before any modifications are made. It is important, however, that a proper evaluation of the results of the modifications is included as part of the testing procedures, and that modifications are not made unless the desired effect is verified.

## E.4 OTHER CONCERNS

### E.4.1 TASTE AND ODOUR CONTROL

A yearly summary of average, maximum and minimum values for carbon dosage for the three year record is given in Table 4.0 of Appendix C.

For the study period, the average monthly carbon dosage varied from  $1.23~{\rm mg/L}$  for February 1984, to  $0.46~{\rm mg/L}$  for March, 1986. Lower dosages than in previous years are evident for 1986.

A daily taste and odour control profile is given in Table 4.1 for the years 1984 to 1986. Only those months in which carbon was used are included.

It was reported that carbon treatment effectively controls tastes and odours in the treated water at the Grimsby W.T.P.

# E.4.2 FLUORIDATION

No fluoride is being added to the treated water at the Grimsby W.T.P. for the reduction of dental decay.

#### E.4.3 ALUMINUM AND IRON

Neither the raw nor treated water is analyzed for dissolved aluminum.

In view of the significance of aluminum residuals in the treated water, it is suggested that at least weekly tests be carried out to obtain this information.

The only metal for which data are available is iron. Monthly analyses of raw water indicate total iron content in the range of 0.019 mg/L to 13.5 mg/L. The high value occurred during March 1985 when the raw water turbidity was 82 FTU.

Monthly analyses of treated water indicate total iron content consistently less than the 0.3~mg/L drinking water objective. The yearly average was 0.013~mg/L for 1986, 0.016~mg/L for 1985, and 0.025~mg/L for 1984; the range for the three-year record was 0.005~to~0.06~mg/L.

# E.4.4 STABILITY OF WATER

The Langelier Saturation Index (L.I.) is commonly used in water conditioning calculations and is defined as:

L.I. = pH - pHs

where: pH = pH of system as measured by pH meter

pHs = saturation pH at which the total alkalinity and the calcium hardness would be at equilibrium with each other and with solid calcium carbonate.

Temperature and total dissolved solids content will influence the value of pHs. If the L.I. is negative and dissolved oxygen is present, water tends to corrode ferrous piping. If the L.I. is positive and water contains much calcium and alkalinity, deposits and scale may form.

The L.I. for Lake Ontario water at the Grimsby plant varied from about -0.22 in the winter to +0.33 in the summer. For the treated water the L.I. was determined at -0.50 in the winter and +0.22 in the summer. The results show that during the winter while undergoing treatment the water becomes slightly aggressive.

SECTION F

RECOMMENDATIONS



#### SECTION F - RECOMMENDATIONS

### F.1 SHORT-TERM MODIFICATIONS

#### F.1.1 PARTICULATE REMOVAL

#### A. Continuous Monitoring of Optimum Coagulant Dosage

Wide and rapid fluctuations in raw water turbidity can have a significant impact on the ability of the plant to produce acceptable treated water quality on a consistent basis. Automatic monitoring of the optimum coagulant dosage would assist in reducing or even eliminating such adverse impact on effluent quality.

#### Recommendations:

- Install a Streaming Current Detector (S.C.D.) to monitor the optimum coagulant dosage as determined in the laboratory by jar tests and/or steaming current titrations.
- 2. Following first-hand experience gained with the operation and performance of a S.C.D., a decision can be reached as to whether automatic dosage control based on a 4 to 20 mA DC output signal from the S.C.D. is warranted. The implementation of this recommendation would require the provision of new chemical feed pumps with automatic speed and stroke adjustment capabilities.
- 3. The optimum coagulant dosage, which is currently selected on the basis of extensive jar tests and the plant's track record, should be documented including methods of evaluation procedures and actions taken and results, in order to establish a productive tool. Jar test results could be plotted (coagulant dosage versus raw water turbidity) in the form of a dosage chart for use by the operators. With time, the chart can be adjusted to reflect the experience of full-scale treatment.

## Estimated Cost:

#### Recommendation 1:

- Supply and install Streaming Current Detector

\$14,000

#### Recommendation 2:

 Supply and install 2 chemical feed pumps with variable speed controller and automatic electric stroke positioner

\$ 9,000

B. Flash Mixing of Coagulant and Operation of Existing Flocculators

Up to 1986 and partly into 1987 the primary coagulant application point was at the 400 mm dia. suction pipe in the raw water well and directly into the well when low lift pump 1 was not operating (pumps 2 and 3 are supplied by a separate 250 mm dia. suction pipe).

In the Spring of 1987 a second coagulant feed system was located in the low lift pump room. The application point for this system is at the 400 mm dia. common discharge header from all three low lift pumps.

The pier pump intake continues to be dosed by the original installation (in the raw water well house) at a point (on the pier) in the 200 mm dia. discharge pipe from the pump.

#### Recommendations:

1. The application of coagulant at the Grimsby W.T.P. is inadequate; although the change made in 1987 is an improvement over the original feed point for the main raw water supply. Optimization of the coagulant process, and for the most efficient use of the coagulant chemical, it is necessary to flash mix the chemical with the raw water at a fraction of a second. This high intensity mixing can best be achieved at the Grimsby plant by installing

chemical injector nozzles, one in the 400 mm dia. common discharge header from the low lift pumps and one in the 200 mm dia. raw water header supplying the pressure filters.

 Operate the existing flocculators at higher speeds in order to increase the efficiency of floc formation and to maximize utilization of the chemical coagulant.

## Estimated Cost:

 Supply and install two injector nozzles and make modifications to chemical feed systems

\$12,000

### C. Flocculant Aid and Other Primary Coagulants

The capacity of the settling basins has been exceeded, especially during the summer demand period. With the addition of a flocculant aid to the process flow it is possible to improve settling performance and thereby extend the capacity of the basins. Other benefits associated with the use of a flocculant aid include a reduction in the alum dosage and hence the amount of alum precipitated sludge that will be produced.

#### Recommendation:

In an effort to improve the performance of the sedimentation and filtration processes at the Grimsby plant, many tests have been carried out by representatives of chemical suppliers that market coagulation polymers and polymer preconditioned primary coagulants (i.e., HyperI+on<sup>TM</sup> by General Chemical Canada Ltd.). Unfortunately, none of the tests with the exception of PACl, proved sufficiently successful to warrant further consideration. For this reason it is recommended that the pretreatment process and unit operations at the Grimsby plant be reviewed in detail by a consulting engineer. Such a study should include a second assessment of the use of flocculant aid polymers and other commercially

prepared primary coagulants. In addition, an in-depth assessment should be made of existing and required mixing facilities.

In Section E of this report it has been concluded that the use of a cationic polymer flocculant aid would be beneficial and result in improved performance of the treatment process. The investigation recommended herein should confirm whether or not polymer storage and feed equipment for the application of a cationic or non-ionic polymer as a flocculant aid should be installed at Grimsby W.T.P.

#### Estimated Cost:

- Supply and install polymer feed system consisting of:
  - drum storage of neat polymer
  - drum transfer pump
  - 1 200 L mixing and solution storage tank
  - 2 chemical metering pumps with flow proportional controls
  - 1 mechanical mixer
    - 1 motionless mixer, piping, valves and rotameter \$20,000

## D. Operation of Pressure Filters

Two primary concerns relate to the operation of the pressure filters; namely:

- during summer operations poor raw water quality is generally drawn from the pier pump intake,
- over the winter pressure filters are shut down which reduces available filter capacity.

With the use of a flocculant aid settling tanks may give adequate performance at higher hydraulic loading rates to allow pressure filters to be operated in parallel with gravity filters with effluent from the settling basins.

#### Recommendations:

- Studies should be carried out to determine the feasibility of operating pressure filters during the winter with water supplied by submersible pump from the effluent section of the sedimentation tanks.
- Effluent turbidity from pressure filters should be monitored on a routine basis

### E. Operation of Gravity Filters

Improvement in overall treated water turbidity may be achieved by improving operations of the gravity filters. The objective is to improve performance by reducing the initial filter breakthrough which occurs immediately following a filter backwash.

#### Recommendations:

- Continue to let filter rest for about 15 minutes after a wash before returning the filter to service, whenever possible.
- Continue to minimize hydraulic surges during start up by slowly opening the filter effluent valve.
- Investigate filtering to drain via the filter drain valve (at low rate) for 15 to 20 minutes as an alternate means of improving filter effluent quality at start-up.

## F.1.2 DISINFECTION

Although the record for disinfection is favourable, certain inadequacies exist which, if improved, could lead to a more reliable disinfection process. The two areas where current practice fall short of design objectives are:

- insufficient contact time, and
- inadequate mixing of chlorine solution with the effluent from the pressure filters

The objective for additional contact time can be achieved by adding chlorine injection points to the discharge of the gravity filters.

Increased contact time for postchlorination of pressure filter effluent can be achieved by chlorinating the individual filter effluent discharges.

Further, the overall efficiency of the chlorination process can be improved by lowering the high water pH and by slightly increasing the post-chlorine dosage.

#### Recommendation:

- Examine the feasibility and prepare cost estimates for changing existing post-chlorine application points to the discharge pipes from each filter.
- Determine the feasibility of adjusting raw water pH, either with the addition of an acid or an acidified coagulant and increasing the post-chlorine dosage, in order to improve the overall efficiency of the disinfection process.
- Periodically test the treated water for TTHM content. CWSP data for THMs should be examined to determine a future test frequency.

## F.1.3 GENERAL IMPROVEMENTS TO PLANT OPERATIONS

## A. Intake

Several problems were identified with regard to the size and location of the existing gravity intake, namely:

- raw water quality at the intake is highly variable because of the proximity of the Forty Mile Creek and the shallow lake water depth at the intake crib;
- the actual intake capacity is limited to about 13,000 m³/d by the high draw-down experienced in the raw water well (indicating that actual head losses incurred by far exceed theoretically calculated values);
- during the winter capacity is severely restricted by frazil ice which gets drawn into the intake. To overcome this problem it has been necessary to greatly reduce flows, thereby limiting intake velocities at the bell mouth, and to backflush the intake, as often as seven times during a single night, with water taken from the distribution system.

#### Recommendations:

- The problem with frazil ice formation at the bell mouth can be partially overcome by installing a compressed air system consisting of:
  - $-1 85 \text{ m}^3/\text{h}$  capacity air blower, 3 kW motor
  - -1 75 mm diameter air line with perforated ring header around bell mouth of intake.
- Remedial measures for improving raw water quality and intake capacity require the provision of a new intake.

A recommendation regarding a new intake is made in the following section on Long-Term Modifications.

# Estimated Cost:

Supply and install compressed air package

### B. Taste and Odour Control

The problem of taste and odour in the treated water has been controlled effectively by the addition of powdered activated carbon.

#### Recommendation:

The practice of using powdered activated carbon treatment for the control of taste and odour in the treated water should be continued.

#### C. Residual Aluminum

The aluminum content in the treated water is of concern primarily because of the phenomenon of post-floc formation in the distribution system and its resultant impact on the carrying capacity of watermains.

#### Recommendation:

Analyze raw and treated water periodically for its aluminum content. Examine DWSP data for aluminum and determine a future test frequency.

### F.2 LONG-TERM MODIFICATIONS

## F.2.1 MODIFICATIONS TO EXISTING PLANT

The following long-term recommendations for improving the operation of the existing plant are conditional upon the Region of Niagara's future expansion and development plans for meeting future water needs of the service area.

# A. <u>Intake</u>

In order to benefit from better and more consistent raw water quality, and to increase capacity, a new larger diameter intake, properly sited in deep water, should be constructed.

### Estimated Cost:

Supply and install 600 mm dia. intake
 by 450 m long

\$500,000

### B. Raw Water Flow Meter

In order to monitor and record raw water flows, and to permit quantitative pacing of chemicals, a raw water flow meter should be installed on the 400 mm diameter discharge pipe form the low lift pumps. This meter could be of the ultrasonic, time transient type, and should be equipped with a flow indicating controller, totalizer, signal transmitter and flow recorder.

### Estimated Cost:

 Supply and install flow meter complete with all instrumentation

\$20,000

### C. Flocculation and Sedimentation Basins

In order to improve cold weather operations of the flocculation and sedimentation basins, existing tankage should be covered and weather-proofed. Options to be considered will depend upon the remaining life of the plant and are:

### Option 1

Install a low height roof using precast, prestressed, hollow-core slabs, or single or double tees.

### Option 2

Enclose the entire tankage in a building equipped with all necessary services. Enclosing of the process units would allow for the future installation of mechanical equipment in floc and sedimentation tanks thereby increasing the performance and capacity of these units.

### Estimated Cost:

### Option 1:

- Supply roof structure, 12.2 m W x 33.5 m L

\$60,000

### Option 2:

- Construct fully serviced building \$400,000 (cost will depend upon type and final to design of building to be erected) \$750,000

### F.2.2 OPTION FOR EXPANDING PLANT CAPACITY

### A. Construction of a New Plant

The Grimsby water service area is currently in an expanding growth situation. Proposals have been made to supply the Town of Beamsville and, most recently, the Town of Smithville with water from the Grimsby Water Treatment Plant.

Due to the growth of Grimsby and the potential expansion of the service area, the capacity of the existing treatment plant is inadequate. This has been known for some time, and the Regional Municipality of Niagara is contemplating development of an entirely new treatment plant. As background information to the Region's planning in this regard, the following presents a brief history and conditions of the existing treatment facilities.

The intake, screen house and pumping station which now includes low lift and high lift pumps with standby gasoline and diesel engine drives, pressure filters, chlorine room and administration offices, are very old and represent the original water supply system that was constructed to serve the municipality of Grimsby. These facilities are overcrowded and not suitable for expansion. The intake and raw water well are at the limits of their capacities. Pretreatment units consisting of flocculation tanks and sedimentation basins, and the filter

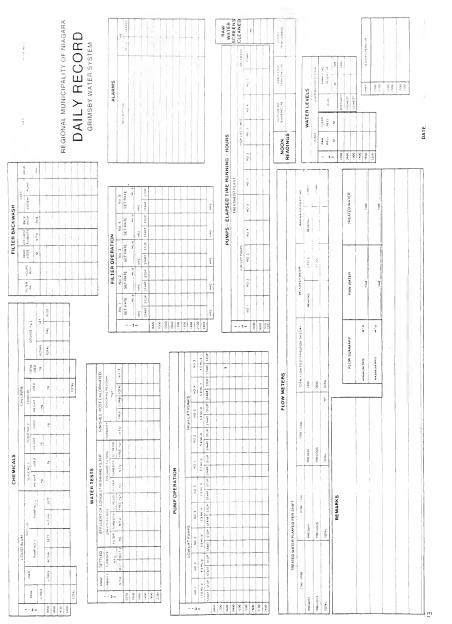
building housing two gravity filters ad a clear well, were constructed in 1957. These treatment units are separate from the inake works and pumping station by two occupied residential homes. Also, the original design capacities have been exceeded. In 1982 the sand filters were renovated and equipped with dual media in order to increase their capacity by utilizing higher filtration rates. Today the maximum hydraulic capacity of these filters is being realized. The preteatment units, however, have never been expanded.

### Recommendation:

In view of the conditions of the existing treatment plant, we endorse the Region's current planning policy for the development of a new water treatment plant on a new site centrally located within the future service area.



APPENDIX A
DAILY RECORD





APPENDIX B

JAR TEST RESULTS

### JAR TEST PROCEDURE

- Obtain sufficient raw water sample to test for raw water quality (turbidity, pH, temperature, colour, alkalinity) and to fill 6 1.5 L glass jars with exactly 1 L of sample.
- 2. Place all 6 jars in the gang stirrer and begin mix at 100 rpm. Quickly add the desired amount of primary coagulant to each jar. Add the coagulant to the vortex created by the fast stirring paddles. After coagulant has been added to the last jar, continue rapid mix for 60 seconds, then reduce the paddle speed to 30 rpm.
- 3. If secondary coagulant is to be used as well, quickly add this in the desired amount to each jar during rapid mix. If the secondary coagulant is a polymer, then this should be added after the addition of primary coagulant. If activated silica is used, then the order of addition should be noted.
- Continue slow mix at 30 rpm for 30 minutes. After 30 minutes, the paddles should be stopped and removed from the jars.
- Following the start of the slow mix, observe the time of the first appearance of visible floc in each of the six jars, and also the appearance, size and quantity of floc at the end of the agitation or flocculation period.
- 6. After 30 minutes of slow mix allow the samples to settle. From a fixed depth of 5 cm, the mid-point of the water depth in the jar, collect samples at 1,2, 4 and 8 minutes after the start of settling and analyse samples for turbidity. Samples drawn at these times represent settling velocities of 5, 2.5, 1.25 and 0.625 cm/min. respectively. Plot the results in terms of settling velocity distribution curves.

7. Following the settling period, pipette 200 mL of supernatant from each jar. Use 50 mL to wet a glass fibre filter disc and discard. Filter the remaining sample and measure the turbidity of the finished water. Use a separate filter apparatus and filter disk for each sample from each jar. Use Gelman Sciences Type A/E 47 mm glass fibre filters or Whatman No. 40 filter discs.

PLANI
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WATER
GR I MS BY

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RAW WATER CHARACTERISTICS

TURBLUTT : 31 1 N1U
COLOUR : 25 ACU
TEMPERATURE : 101 C

JAR TEST NUMBER

GRIMSBY	GRIMSBY WATER TREATMENT PLANT	MERT PLANT						COLOUR		0 0				
7	JAR TEST RESULIS	00.15						i EMPEKA I UKE pil	7.95	٠.				
	COAGULANI		FLUC CHARACTERISTICS			<u> </u>	_	SEI	SETTLED WATER	ER SAMPLES	ES .			FILTERED WATER
JAR		Time to list floc	Appearance	Size	Quantıty	Time (min:sec)		Time [min:sec]	Turbidity (NTU)	Time [min:sec)	Turbidity (NTU)	Time (min:sec)	[Lurbidity]	-
-	A lun 8	25 min	mostly pin floc; some smaller floc particles forming on particulates	E .	-	5:00	12 6	3:00	s s	4:35	1.6	10:50	5 2	60 0
2	A lum 12	12 min	small floc; stringy in shape	Ē	e e	1:45	5.5	2:50	3.9	4:25	3.9	10:25	2.5	90 0
m	A lum 16	: :: ::	floc slightly spherical in shape, floc is more dense than that formed with 12 mg/L	2	m	30	0 E	2:40	2.3	4:15	2.2	10:00	/6.1	90 0
4	Alum 24	3 min	mostly spherical floc; compact in appearance; size of floc not homo- genous	E 2	4	1:15	2.1	2:30	1 67	4.00	1.21	9:35	0.38	0.05
<u>ه</u>	Alum 32	2 main	mostly spherical floc; Lompact III appearance, Size of floc not homo- genous	2 mm	ਚ	0	a a	2:20	16	3.45	1 45	01:6	34	0.03
	A lun 48	2 main	Size is more homogenous (than in jars 3,4 and 5, flow not as dense as in jars 3,4 and 5	i -	S	0.50	23.3	2.10	0 9	3:30		8:50	60 1	0 05

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JAK	-	
31.2 810	. 25 ACU	
1018810117	COE OUR	

ORIMSBY	GRIMSBY WALER TREATHERLE PLANE JAR TEST RESULTS	MENT PLANT				HAW WAILE	RAM WATER CHARACLIERISTICS		LURBIOLIY COEOUR IEMPERALUR PH	. 31.2 NHU . 25 ACU : 10° C : 7 93	)   	JAR LEST NUMBER	IUMBER. 2		
			FLOC CHARACTERISTICS			1		SET	SETTLED WATER	ER SAMPLES	53			FILTERED WATER	
JAR	and DOSE (mg/L)	lime to	Appearance	Size	Quant ity	Size Quantity (min.sec)	-	٤	Turbidit (NTV)	y Time    (min:sec)	Time   Turbidity  in:sec)  (NfU)	_	Time [Turbidity]	SAMPLES Turbidity   (NIU)	
-	A lum	81	Slightly larger than pin 0.5 mm lloc, Size not very homogenous, lairly dense	0.5 mm	~	1.40	0 9	2:50	7.4	04.4	9 4	8:40	3.2	4.	
~	A lum 12	12 mm	mostly spherical shape; farrly dense; size slightly more homo- genous than jar L. with a lighter structure		m	30	£.	2:40	2.5	4:30	2.4	8:30	1.68	0.09	
m	A lum	80 E	mostly spherical shape; larrly dense; size slightly more homo- genous than jar L, with a Lighter structure	W 2	4	1:20	7.2	2:30	1.58	4.20	1.57	8:20	1.2	50 0	
4	A Tum 16	9	mostly spherical shape; farrly dense; size slightly more homo- genous than jar i, with a lighter structure		4	9	3.2	2:20	1.46	01	95.	8:10	1.20	0 15	
s	A lum 20	4 E	mostly spherical shape; [airly dense, size slightly more homo- genous than jar l, with a tighter structure	2 III	4	90:	2. 4	2:10	1.44	00	20.1	. 00:8	0 87	11.0	
٥	A lum 24	4 min	Size is more homogenous than in jars 3.4 and 5	2 mm	4	0:50	5 4	2:00	1.43	3:50	90.1	7:50	0.74	0.08	

GRIMSBY WATER TREATMENT PLANT

JAR 1EST RESULTS

TURBTOTTY COLOUR RAW WATER CHARACTERISTICS :

JAR TEST NUMBER.

40 1 NIU

25 ACU TEMPERATURE H

10. C 7.98 FILTERED WATER urbidity SAMPLES (NTU) 0 04 91 0 60 0 0.04 0 04 0.03 I me Turbidity 97.0 0 17 1.03 0 49 (min:sec) (NIU) 8 8 8.8 7.50 8:10 8.00 8:40 8:30 8:20 Time [Turbidity] Size |Quantity|(min.sec)| (NIU) |(min:sec)| (NIU) |(min:sec)| (NIU) 0.17 1.10 0.53 0.35 3.9 SAMPLES 3:30 4:50 4:20 3.40 4.40 4:30 SETTLED WATER Time [Turbidity] 0.24 1.15 0.63 0.32 4.0 5:00 2:50 2:40 2:10 2:30 2:20 Time | Turbidity 1.21 0.64 0 64 5.6 13.8 5.5 0:50 1.40 1:30 1:20 1:10 1:00 S 3 2 2 2 mm 2 mm 3 mm 3 mm HER I nı d FLOC CHARACTERISTICS not as dense as floc in some difference in size dense, tight structure; dense, tight structure; dense, tight structure; fairly dense, tight Appearance spherical shape; spherical shape; spherical floc; homogenous size spherical floc; homogenous size spherical floc: homogenous size Jars 3,4 and 5 small floc; pın Floc; structure 1st floc 4 min 40 sec 25 mm 30 sec 20 sec 10 sec I me to COAGULANT and 005£ (mg/L) PAC 2 PAC 4 PAC PAC PAC PAC 12 16 24 8 NUMBER S 9 JAR 2 e

GRIMSBY WATER TREATMENT PLANT

JAR TEST RESULTS

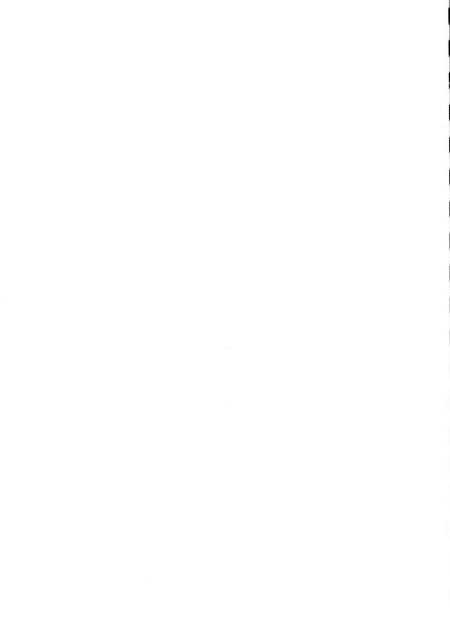
KAN WATER CHARACTERISTICS: TURBIDITY
COLOUR
TEMPERATURE

JAR TEST NUMBER.

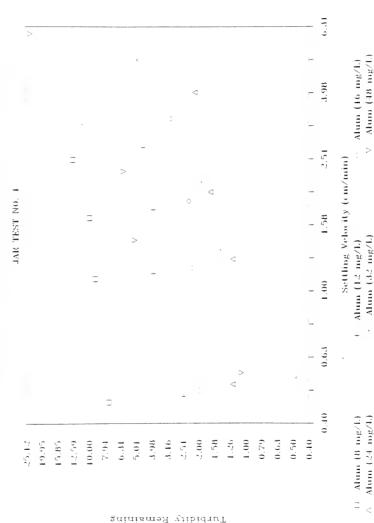
30.4 NTU : 25 ACU : 10° C

	FILIERED WATER	Turbidity (NTU)	0.08	0.07	0.07	90.0	0.05	0 05
	FILLE			~				
		Turbidi   (NTU)	2.0	1.42	76.0	0.49	0.49	0.45
	_	Time  (min:sec	8:40	8:30	8:20	8:10	9:00	7:50
1.92	ifS	Turbidity   (NTU)	9. e	1.54	1.04	0.68	0.61	0.58
표	WATER SAMPLES	Time (min:sec)	4.40	4:30	4:20	4 : F0	4:00	3:50
	SETTLED WA	Turbidity (NTU)	e	1.72	1.06	0.67	0.62	0.77
1	SS	Time  Turbidity  Time  Turbidity  Time  Turbidity  Time  Turbidity  (MIU)   (min.sec)  (MIU)   (MIU)   (min.sec)  (MIU)   (min.sec)  (MIU)   (min.sec)  (MIU)   (min.sec)  (MIU)   (min.sec)  (MIU)   (MIU)	2:40	2:30	2:20	2:10	5::00	1:50
		Turbidity (NTU)	6. 4.	96 1	1.05	0.86	0 65	96.0
			1:40	1:30	1:20	01:1	06:-	0: 20
		Quantity (1 to 5)	~	4	·	'n	S.	s
		Size		2 HB	E .	3	E	E 7
P   P   P   P   P   P   P   P   P   P	FLOC CHARACTERISTICS	Appearance	Structure more stringy frather than spherical; size not homogeneous; not as dense as floc in lars 2 to 6	spherical floc;  dense, tight structure;  homogenous size	spherical floc; dense, tight structure; homogenous size	spherical floc; dense, tight structure; homogenous size	spherical floc; dense, tight structure; homogenous size	spherical shape; hot as dense as floc in jars 3,4 and 5
		lime to list floc	10 m n	2 11110	e -	30 sес	30 sec	30 sec
	CUACUL AN	and DOSE (mg/L)	PAC 4	PAC 6	PAC B	PAC 10	PAC 12	PAC 16
		JAK	-	2	м	4	9	٥

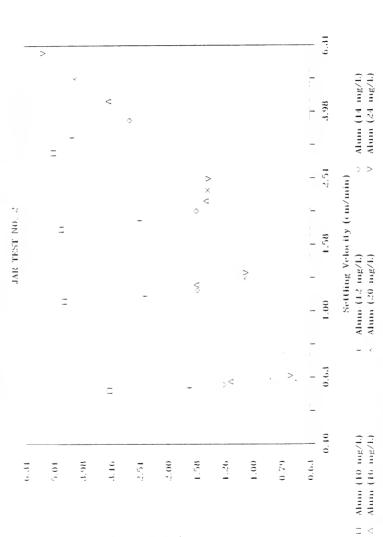
GRIMSBY	GRIMSBY WALER TREALMENT PLANT	SENT PLANT	_	RAW WAS	ER CHARAC	RAW WATER CHARACTERISTICS	_ (	URBIDITY	35.7 NTU	NIO :	JAR TEST NUMBER	NUMBER. 5		
	JAR JEST RESULTS	JLTS		1		1 1 1 1 1 1 1	J = 4	COLOUK TEMPERATURE pH	. 25 AUU . 10° C . 7 95	3				
	INV HISTORY	<u>.</u>	FLOC CHARACTERISTICS					SE	SEFTLED WAT	WATER SAMPLES	ES			FILTERED WATER
JAR  NUMBER			Appearance	Size	Quantity (I to 5)	Time (min:sec)	Quantity  Time  Turbidity   (I to 5) (min:sec)  (NTU)	Time (min:sec)	Time [Turbidity] (min:sec)] (NTU)	Time (min:sec)	Time   Turbidity		Time   Turbidity  min:sec)  (NTU)	Turbidity (NTU)
	Alum 14	9	structure more stringy rather than spherical, size not homogeneous; fairly dense structure	Ī	m	I:40	4.2	2:40	80 E	4:40	0 4	8: 40	3.2	0.13
2	Alum 16	0 min	spherical floc; not as large or dense as floc formed with PAC; size is fairly homogenous	E 2	4	1:20	2 6	2:20	2 0	4:20	1.85	8:20	1 48	60 0
m	Alum 18	S 8	spherical floc; not as large or dense as floc formed with PAC; size is fairly homogenous	2 mm	4	1:00	မှ ဗ	2:00	2.4	4:00	2.2	00:90	2.0	0.13
4	PAC 1	5 min	spherical floc; dense, tight structure; tairly homogenous size	3 11	4	1:30	99.	2:30	1 63	9.30	1 43	8:30	1.33	0 10
رم د	PAC 8	2 m.n	spherical floc; dense, tight structure; fairly homogenous size	E .	4	1.10	1 61	2:10	1.59	4.10	1-45	9.10	1.38	80 0
9	PAC 9	4 min	spherical floc;  dense, tight structure;  fairly homogenous size	3	4	0:50	1 43	1:50	1 27	3.50	1 .18	7:50	0.63	60 0



# SETTLING VELOCITY DISTRIBUTION CURVE.

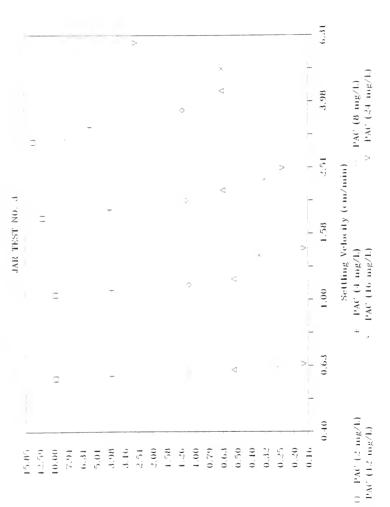


# SETITING VELOCITY DISTRIBUTION CURVE

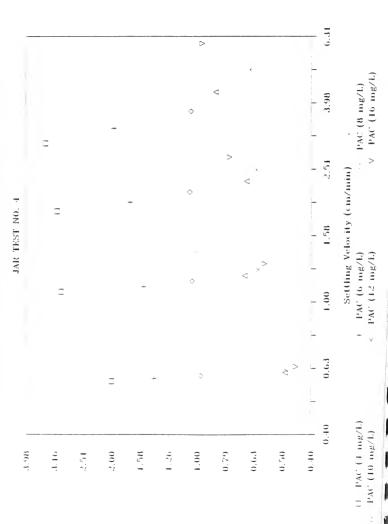


Turbidity Remaining

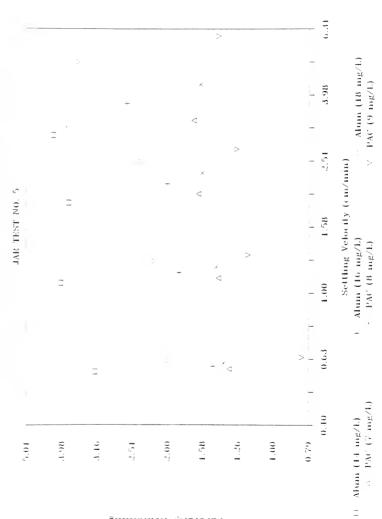
# SETTLING VELOCITY DISTRIBUTION CURVE



# SETTLING VELOCITY DISTRIBUTION CURVE



# SETTLING VELOCITY DISTRIBUTION CURVE



Turbidity Remaining

APPENDIX C
TABLES OF OPERATING RECORD



### TABLE 1

WATER PLANT OPTIMIZATION STUDY
"PLANT FLOWS"



### MOE WPOS PROTOCOL

HAN,   HIN,   AVG,   HAY,   HIN   AVG,   HAX,   HAN,   H		_		1986			1985			1984			1983	
1	'_		HAX.	HIN.	AVG.	MAX.	E	AVG.	HAX.	E	AVG.	MAX.	X.	AVG.
R   7,297   5,724   6,542   6,108   5,159   5,504   6,637   R   1   7,320   5,951   6,564   6,233   4,860   5,547   5,446   R   1   7,561   5,830   6,552   7,075   4,790   5,869   5,892   R   1   1,820   6,024   7,914   1,871   5,723   7,735   6,955   R   1   1,332   6,407   7,977   12,310   5,536   8,257   11,297   R   R   1   1,880   4,837   7,916   4,026   5,495   9,461   11,497   R   R   1   1,880   4,837   7,916   4,026   5,495   9,461   11,497   R   R   R   R   R   R   R   R   R		~ <del>-</del>	6.599	5,363		6.101	3.441	4.915	6.073	4.673	5.293		-	1
R   7,320   5,951   6,564   6,233   4,860   5,547   5,446   R   R   7,561   5,830   6,552   7,075   4,790   5,360   5,892   R   R   11,332   6,407   7,914   11,871   5,723   7,735   6,955   R   R   11,332   6,407   7,977   12,310   5,536   8,257   11,297   R   R   R   R   R   R   R   R   R	<u>-</u>	~ <b>-</b>	7.297	5.724	6.542	6.108	5.159	5.504		4.591	5.448	.		
1	<u>-</u>	~ <b>-</b>	7.320	5.951	6.564	6.233	4.860	5.547		4.096	4.796	1	:	1
H   10.820   6.024   7.914   H.871   5.723   7.725   6.955   R   H.1.332   6.407   7.977   12.310   5.536   8.257   H.297   R   H.3406   6.015   3.188   H.355   6.015   9.227   H.251   R   R   H.380   4.837   7.916   H.026   5.495   9.461   H.497   R   R   R   R   R   R   R   R   R		~ - !	7.561	5.830		7.075	4.790	5.360	5.892	4.387	5.104	1		
H   11.332   6.407   7.977   12.310   5.536   8.257   11.297   13.406   6.015   3.188   13.555   6.015   9.227   11.251   11.880   4.837   7.916   14.026   5.495   9.461   11.497   10.579   5.680   7.236   9.317   5.370   7.527   7.660   R   R   R   R   R   R   R   R   R		<b>≃</b> ⊢	10.820	ا ف	7.914		5.723	7.735	6.955	4.841	5.577	1		
R   R   R   R   R   R   R   R   R   R	 E	<b>∝</b> ⊢		9		12.310	5.536	8.257	11.297	5.014	7.294			
R   1, 880   4,837   7,916   14,026   5,495   9,461   11,497   R   1   10,579   5,680   7,236   9,317   5,370   7,527   7,660   R   F   7,454   5,609   6,554   7,830   5,197   6,665   7,901   R   R   R   R   R   R   R   R   R	∸ <b></b> -	~ <del>-</del>			3.188	13.555		9.227	11.251	5.510	8.026			
R   10.579   5.680   7.236   9.317   5.370   7.527   7.660   R   R   R   R   R   R   R   R   R	<u></u> -	<b>≃</b> ⊢	11.880		7.916		5.495			5.351	7.860			1
R   7,454   5,609   6,554   7,830   5,197   6,665   7,901		<b>∝</b> ⊢	10.579		7.236	9.317	5.370	7.527	7.660	4.719	6.117		-	
		<b>∝</b> ⊢	7.454	5.609	6.554	7.830	5.197	6.665	7.901	5.023	6.540	1		
R	 ≥	~ -	969.9		5.641	6.942		5.805	6.114	4.628	5.192			
D20.0 000.0 120.0 000.0 000.0 000.0 000.0		<b>≃</b> ⊢	6.546	4.180		6.540	5.524	5.956	5.528	4.023	4.980			

f 2					4		2						 									 ::
Page 1 of	DEC	5,553	5.425	5.297	5.324	5.554	5.442	5.031	5.754	5.558	5.373	5.521	5.303	5.236	5.205	5.616	5.133	5.798	5.091	5.723	5.53	5.228
Pa	NON	1	1	1			6.331	6.403	6.053	5.124	5.296	5,394	5.430	5.473	5.067	6.624	5.706	5.934	5.733	5.286	5.172	5.262
	100		1	7.004	7.270	7.058	6.655	6.745	6.880	6.876	6.889	6.959	6.760	7.435	6.587	7.355	6.942	7.454	7.172	5.922	5.973	6.073
	SEP	10.167	10.579	9.979	9.116	8.088	7.535	7.489	8.275	8.273	6.908	5.915	6.318	6.380	5.680	6.465	6.493	6.062	6.711	6.223	5.969	5.398
	AUG					6.887	4.837	5.807	968.9	7.808	7.482	6.122	6.057	6.296	5.593	6.853	6.256	7.322	6.810	8.139	9.383	9.266
10001	301		11.004	7.839	9.710	9.498	12.610	13.406	10.066	6.867	8.371	9.730	7.746	6.015	6.139	6.884	7.821	6.835	6.416	659.9	6.315	6.020
MOE WPOS PROTOCOL	JUN							7.388	7.741	7.643	8.377	6.474	6.451	6.925	7.085	8.322	7.469	7.015	6.504	7.032	7.730	6.407
	MAY				6.838	7.410	7.293	6.559	8.208	7.475	7.440	1.7.1	7.530	9.129	9.300	8.498	8.709	7.242	8.457	7.091	8,207	9.351
é √d) 198 <u>é</u>	APR		6.739	6.334	7.049	6.454	6.156	6.110	6.435	6.565	6.227	6.028	6.133	6.742	6.744	7.300	6.481	5.830	5.918	7.304	6.808	6.017
WS (ML	MAR		1				7.320	6.619	7.156	6.889	6.636	6.499	6.850	6.555	6.119	7.077	6.047	6.294	5.951	6.532	6.412	6.010
DAILY FLOWS (ML/d) 1986	PREATED WATER		1 1 1 1 1 1		; ; ; ;	1	6.039	5.724	6.107	6.613	5.941	6.408	6.025	6.320	5.887	6.252	969.9	6.215	6.177	7.033	6.634	069.9
=	JAN		1	5.386	5.384	6.034	6.011	5,363	6.106	6.075	6.209	0.00	6.367	6.599	5.853	6.170	6.100	6.564	6.126	6.470	6.378	5.873
TABLE	DAY	¥ O	3	3	3	- E	SAT	SUM	NOM	30.	G.	3	æ	SAT	SUN	NO.	3	E.	3	E	SAI	SUM

TABLE 1.1 (cont'd.) 1986

	TREAT	TREATED WATER										
DAY	JAN	FEB	HAR	APR	MAY	NA.	JII.	AUG	SEP	001	NON	010
NON	6.156	7.297	889.9	6.335	6.545	7.228	6.750	10.562	6.503	7.136	6.200	5.970
301	6.094	699.9	6.268	6.431	6.024	7.069	7.642	11.880	6.424	6.628	5.393	5.845
NED.	6.030	7.001	6.340	6.851	7.127	8.324	8.228	10.095	7.310	6.258	969.9	6.085
1 3	6.415	7.059	6.953	6.299	6.708	886.9	9,668	10.599	6.782	5.830	5.494	5.462
FRI	5.947	6.932	6.259	6.893	6.161	8.858	9.387	10.779	008.9	6.052	5.263	6.048
SAI	5.884	7.050	6.743	7.446	7.303	11.332	6.485	7.505	7.485	6.070	5.782	4.180
SUN	5.737	6.342	6.143	6.621	8.047	9.336	6.967	8.634	7.245	5.870	5.267	6.105
NO.	6.316	7.911	6.333	7.561	8.592	9.462	8.057	10.451	6.748	990.9	6.262	4.985
10E	6.228	6.933	6.487	6.275	6.877	8.069	7.567	9.017	7.252	5.906	5.537	4.883
WED	6.090	6.832	6.807	6.476	8.166	8.273	8.404	6.878		5.900	5.254	965.9
1 3	5.865	6.346	6.020		10.820	11.088	8.725	6.823		5.824	5.481	
FRI	5.947	6.949	6.771		10,500	8.718		7.573		5.609	5.691	
SAT		!	6.993		9.908	8.821	1	8.721			5,313	
SUN			6.365		1	8.268		8.121			5.270	-
¥Q.	<u> </u>		6.845			9.934						
TUE	<u> </u>		! !									
¥	6.599	7.297	7.320	7.561	10.820	11.332	13.406	11.880	19.579	7.454	969.9	6.546
E	5.363	5.724	5.951	5.830	6.024	6.407	6.015	4.837	5.680	5.609	5.067	4.180
AVG	6.073	6.542	6.564	6.552	7.914	1.971	8.188	7.916	7.236	6.554	5.641	5.478
										-		l

MOE WPOS PROTOCOL

	THE	THEATED WATER	ER.									4
DAY	JAN	FEB	MAR	APR	ΜAΥ	NE S	3	AllG	SEP	100	NOX	DFC
 NG				5.698			11.136					
INE	4.301			5.590			9.948			7.279		
1 03	4.705			5.610	6.595		11.947	 		7.830		
1 2	4.637			5.935	6.565	1	13.555	11.713		7.719		
=	4.755	5.369	5.546	5.155	7.623		12.895	14.026		7.758	5.692	
SAT	5.128	5,399	5.685	5.381	7.103	6.642	7.143	13.915		7.122	5.685	
- NOS	4.314	5.309	5.400	4.790	5.728	7.350	6.735	13.515	5.370	6.358	5.301	5.701
- ME	5.128	5.992	5.484	5.471	6.437	8.279	7.566	12.536	6.052	7.663	5.715	5.933
121	4.628	5.484	5.674	5.884	6.473	8.186	7.100	12.983	7.179	7.390	5.308	5.970
03	3.441	5.182	5.583	5.510	6.601	7.810	6.335	8.887	7.631	6.620	5.631	5.674
1 3	4.050	5.644	5.241	5.390	6.876	10.231	8.632	10.984	7.162	7.628	5.388	5.546
=	4.296	5.784	170.9	5.620	7.902	10.619	6.537	13.733	6.779	7.084	5.483	6.064
SAT	4.591	5.569	5.355	5.500	10.235	10.979	7.183	13.547	7.945	6.757	5.584	5.952
SE	3.746	5.305	5.491	5.209	8.709	10.259	6.015	13.673	6.011	5.777	4.957	5.798
N. S.	4.528	6.108	5.249	6.093	10.218	12.310	7.292	12.388	6.863	5,653	5.553	5.978
13	4.501	5.410	4.860	6.178	9.747	. 6	6.604	12.202	6.677	6.963	5.363	5.574
1 03	4.341	5.642	5.350	6.570	6.545	7.043	7.449	13.023	6.639	6.621	5.572	5.705
3	4.359	5.369	5.627	5.003	7.951	608.9	8.092	8.272	6.832	6.524	6.198	6.226
=	5.308	5.661	6.070	5.533	7.526	7.139	7.738	6.822	7.278	6.964	6.203	5.867
SAT	5.135	5.841	5.433	5.703	8.132	7.807	6.842	7.235	7.286	6.308	6.028	6.074
SUN	5.033	5.402	5.295	5.452	7.827	5.901	6.543	6.962	5.494	5.932	5.849	5.619
Ī												

TABLE 1.1 (cont'd.) 1985

DAY	JAN	N FEB	HAR	APR	Ψ¥	NA.	N N	AUG	2	3		
	5.258	5.482	5.705	6.768	9.102	6.436	8.448	6.733	7.901	6.873	6.329	5.989
132	6.101	5.544	5.995	6.522	7.436	6.594	9.625	65.369	7.796	6.248	6.087	5.941
T Q	6.015	5.368	5.725	6.058	6.961	6.547	11.510	7.306	7.894	5.949	6.406	5.783
1	5.697	5.212	5.744	6.315	8.256	5.536	11.934	7.928	9.259	6.068	6.942	5.889
18	5.798	5.385	5.787	5.802	10.525	7.421	10.455	7.866	9.281	6.857	5.918	6.135
SAT	5.502	5.159	5.670	7.075	11.371	5.322	11.631	5.996	8.272	6.284	5.953	6.160
SEN	5.072	5.369	5.073	5.489	7.919	6.281	13.492	5.495	8.779	6.226	5.717	5.859
3	5.694	5.582	6.117	6.908	6.977	7.766	13.063	6.843	9.317	6.270	5.933	6.292
<u></u>	5.216	5.545	5.711	6.805	6.915	8.377	13.185	6.517	7.801	5.563	5.610	6.540
93	5.755		5.621		7.238	9.045	9.337	6.549	7.542	5.197	5.836	5.524
3	5.336		5.325		7.404	10.270		6.590	7.810	6.129	6.221	6.312
FRI			4.880		6.528	10.487		6.485	7.517		5.817	6.022
SAI			6.233			10.114		5.706	8.096		5.863	6.302
S			4.953			9.724			9.220			5.644
NO.						1		_	8.132	-		6.035
TUE												6.527
¥.	6.101	6.108	6.233	7.075	11.871	12.310	13,555	14.026	9.317	7.830	6.942	6.540
Ŧ	3.441	5.159	4.860	4.790	5.728	5.536	6.015	5.495	5.370	5.197	4.957	5.524
AVG	4.915	5.504	5.547	5.860	7.785	8.257	9.227	9.461	7.527	6,665	5.805	5.956

9 IUE MED Ξ FRI SAI SUN Ş

5.323 4.669 5.205 4.992 5.151 5.114 5.001 4.823 4.905 4.992 5,069 4.955 DEC. 4.987 5.369 4.628 4.814 4.910 5.33215.610 5.132 5.110 5.060 4.973 5.142 4.828 5.132 4.855 4.992 5.246 2 6.478 7.051 6.742 7.174 1.90.7 7.796 | 1 870.7 6.601 6,237 7.046 6.755 6.542 6.592 7,396 6.246 5.864 6.614 1.337 018.9 5.737 7.460 0 5.173 690.9 4.719 5,459 5.705 699.5 6.2195.783 5.859 5.046 4.969 5.992 5.632 5.046 5.987 6.245 SEP 9.851 5.351 6.892 6.187 9.342 8.078 6.701 6.142 6.342 6.478 7.246 B. 106 7.892 8,496 11.497 9.851 10.847 9.392 8.346 AUG 7.746 6.119 7.615 5.569 9.369 9.442 8.610 6.1237.355 5.510 6.783 8.451 100.8 7.628 5.778 Ħ MOE WPOS PROTOCOL 7.624 8.165 7.628 8.328 5.014 5.182 11.297 10.679 6.724 9.533 10.369 11.160 10.01 6.642 6.001 8.051 5.601 š 5.037 5.492 6.005 5.159 5.542 5.182 5.269 5.182 5,269 5.583 5.446 4.959 6.492 1695.5 5.282 5.014 5.101 4.982 5.905 5.693 ¥ 4.937 5.514 4.619 4.696 5.032 4.596 4.387 5.105 5.232 5.151 4.751 4.869 4.878 5.182 4.728 APR 5.014 4.614 4.096 4.391 4.691 4.578 4.723 4.914 4.773 4.951 4.751 5.214 4.669 4.855 4.509 4.732 5.092 4.796 HAR PREATED WATER 5.887 5.282 5.264 5,332 5.409 4.651 5.082 5.751 5.192 5.337 5.587 5.573 6.637 5.628 5.746 5.192 6.242 6.409 5.460 FEB 4.673 5.073 5.587 4.819 5,196 5.719 5.273 5.082 5.351 5.29.2 4.809 5.073 5,355 966.5 5.364 JAN

MED.

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TABLE 1.1 (cont'd.) 1984

DAY	JAN	2	ž				-					
-			-	2			_	-	_	- 1	- 000	0 0 0
- NOH	5.501	5.278	4.978	4.992	6.810	5.678	7.705	7.910	6.4461	6.633	1265.5	014.0
	5 3091	5.5281	4.873	5.269	6.955	5.514	5.546	7.974	6.164	969.9	5.292	5.137
	1	5 319	4.278	4.919	6.033	6.487	6.587	6.724	6.514	6.055	5.373	4.923
	4 882	5.555	4.678	4.855	6.146	6.614	7.501	8.351	6.273	6.924	5.137	5,305
	5.55	5.273	1	5.332	6.137	7.001	9.156	8.992	6.733	6.160	5.160	4.969
	1805 5	5.242	-	5.696	1 960.9	7.587	8.360	8.783	6.901	5.605	5.009	5.092
- I - NOS	5.005	1	1	4.559	6.055	5.214	10.106	9.465	6.128	5.023	4.823	4.382
- NOM	6.078	5.796	4.9961	5.228	5.346	6.128	9.547	8.010	6.755	5.614	5.510	5.460
	5.228	4.591	5.446	5.069	4.841	6.159	10.992	6.401	7.660	5.496	5.960	4.028
- 03	5 082	;	   4.978	5.582	4.869	5,619	8.037	5.605	6.674	5.064	4.878	4.819
- =	5 569	1	4.682	5.578	5.446	5.987	7.805	6.064	7.342		5.028	4.869
	1		4.851	5.637		6.301	5.873	6.337	7.369		5.028	5.001
- IAS	000		4.705	1		6.505	9.247		6.610			4.823
- 5				1			10.151		6.378			4.023
	 			5.892			10.833					4.950
<u>=</u>	5.351						11.251					
	6.078	6.637	5.446	5.892	6.955	11.297	11.251	11.497	7.660	7.901	L	5.528
¥   Z	4.67	1	4.096	4.387	4.841	5.014	5,510	5.351	4.71	5.02	4.628	4.02
AVG	5.29	5.448	4.796	5.104	5.577	7.294	8.026	7.860	6.11	6.540	5.19	4.980



#### TABLE 2

WATER PLANT OPTIMIZATION STUDY
"PARTICULATE REMOVAL SUMMARY"



# TABLE 2.0: PARTICULATE REMOVAL SUMMARY

				1986			1985			1984	_		1983	
			HAX.	H.	AVG.	MAX.	MIN.	AVG.	MAX.	Ξ Ξ	AVG.	MAX.	Z Z	AVG.
JAN	   Turbidity (FTU) (1)	1) R	42.00	0.80	14.1	81.50	1, 10	22.7	15 00	1 60	5 53			
-	(6)		0.67	80.0	0.26	1.60	0.09	0.27		0.12	0.22	_		_
	nt <sup>(2)</sup>	(mg/L)	*	*	*	86.97	19.20	48.76		17.47	28.90			
	Coagulant Ald   Filter Ald   Metal Res. Al/Fe (	(mg/L) (mg/L) (mg/L) R												
	Hd -	<b>⊢</b> ∝ :			8.1			8.1			8.4			
	Temperature	( <sup>o</sup> c) R	1.5	0	0.1	2.0	0	0.3	0	0	8.3 0			1
FEB	Turbidity (FTU)	<u>α</u> ,	38.60	7.23	18.8	34.83	3.20	18.8		1.98	20.6			
	jt.	(mg/L)	0.32	0.11	0.18 9.86	0.65	0.18 28.77	0.36 52.12	09.0	0.15 15.79	0.28 45.11			
	Coagulant Ald   Filter Ald   Metal Res. Al/Fe (	(mg/L) (mg/L) (mg/L) R												
	Hd.	<b>-</b> ∝ :			8.1			8.2			8.2			
	Temperature	( <sup>0</sup> C) R	0	0	7.5	2.0	0	0.3	2.5	0	8.0 0.9			
<b>A</b> A	Turbidity (FTU)	~ F	48.30	0.86	12.0	116.20	6.00	33.9		5.13	22.7			
	Prime Coagulant   Coagulant Aid   Filter Aid   Hetal Res. Al/Fe	(mg/L) (mg/L) (mg/L) R	26.13	2.03	7.92	76.01	67.35	51.12	1.10 85.32	93.14 33.14	62.05			
					~						α σ			
	nperature	(°C) R	4.5	0	7.9 0.9	4.5	0	1.4	0.1	0	7.6			
			MAN	MIN	CINC			i				1		

The unit of measurement at Grimsby is NTU. Alum used until January 26, 1986, Polyaluminum Chloride thereafter. Ξ (2) AVG. 34.33 39.93 13.26 MIN. 9.92 30.54 MAX. 53.49 51.55 Polvaluminum Chloride \* Liquid Alum Dry Alum

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				1006			1985			1984			1983	
			MAX.	MIN.	AVG.	MAX.	H.N.	AVG.	MAX.	HIN.	AVG.	HAX.	N.	AVG.
APR	   Turbidity (FTU)	œ	69.50	1.01	13.11	144.80	2.10	23.9	125.80	6.70	29.8			
				0.10	6.73	72.44	20.90		106.07	21.96				
	Frime Loagulant   Coagulant Aid   Filter Aid	(1/6m) (1/6m)												
	Metal Res. Al/Fe	_								_				
	Hd.	<b>-</b> ∝ 1			8.4			7.9			8.2 7.4			
	l   Temperature	(°C) R	R 10.0	3.0	5.0	8.5	2.0	5.0	7.5	1.5	4.3			
Æ	Turbidity (FTU)	~	<u>-</u>	1.20	4.75		3.60 1.60	2.3		1.60				
		<u> </u>	2.50	60.0	0.30		0.171 0.10	0.13	65.40	13.43	35.70			
	Prime Coagulant   Coagulant Aid   Filter Aid	(mg/L) (mg/L)	23.69	26.1	. 8. . 8.			50.07						
	Metal Res. Al/Fe	_												
	¥d.	- ∝ -			8.3			8.5			8.3			
	Temperature	$(^{0}C)$	15.5	5.5	8.8	12.0	7.0	9.1	10.0	5.0	7.0	-		
SUN	Turbidity (FTU)	æ,	<u>!</u>	0.95	2.25		2.50 1.20	1.69	23.00	1.80	5.9			
	   Prime Coagulant   Coagulant Aid	(mg/L) (mg/L)	8.51		5.03	• •	24.61 11.22	18.64		11.29				
	Filter Aid   Metal Res. Al/Fe	(mg/L) (mg/L)												
	Hq -	- œ r			8.2			8.3			8.5			
	   Temperature	(OC)	14.5	8.0	12.1				16.0	8.0	11.7			
			_											

TABLE 2.0 (cont'd.)

				1986			1985			1984			1983	
			HAX.	HIN.	AVG.	MAX.	E.	AVG.	MAX.	MIN.	AVG.	MAX.	HIN.	AVG.
	Turbidity (FTU)	oz ⊦	12.20	1.00	3.16	6.40	1.05	1.78	3.50	1.50	2.0			
	Prime Coagulant   Coagulant Aid   Filter Aid   Metal Res. Al/Fe	(mg/L) (mg/L) (mg/L)	11.88		6.52		11.80	18.07	36.88	16.99	24.77			
	pH	(1/61)			8.2			8.6			8.5			
	Temperature	$(^{0}C)$ R	20.0	9.0	8.2 16.7	18.0	7.0	12.9	16.0	6.5	11.8			
AUG	Turbidity (FTU)	<b>α</b> -	20.70	1.65	4.39	33.50	1.10	6.21	25.70	1.50	5.8			
	Prime Coagulant Coagulant Aid Filter Aid Metal Res. Al/Fe	(mg/L) (mg/L) (mg/L) (mg/L) R	11.69		6.36	45.53	12.37			13.96	32.13			
	pH   Temperature	я 1 В (°С)	20.0	11.0	8.3 8.1 17.8	20.0	12.0	8.4 7.8 17.8	22.5	15.0	8.5 7.9 19.1			
SEP	Turbidity (FTU)	æ I	26.20	i	4.37	16.85	1.90	5.97	31.80	2.20	9.1	!	<u>-</u>	!
	Prime Coagulant   Coagulant Aid   Filter Aid   Metal Res. Al/Fe	(mg/L) (mg/L) (mg/L)	96.6	3.40	5.92	40.39	11.87	23.57	66.52	20.07	36.56			
	됩	- ex H			8.8			8.2			8.2			
	Temperature	(OC) R	16.5	11.0	13.6	20.5	15.0	17.5	18.5	0.11	14.8			

				1986			1985			1984			1983	
			HAX.	H.	AVG.	MAX.	MIN.	AVG.	MAX.	HIN.	AVG.	MAX.	MIN.	AVG.
001	Turbidity (FTV)	æ +	16.58	1.40	5.58	22.60	1.81	4.35	17.96	1.70	5.79			
	Prime Coagulant Coagulant Aid Filter Aid Metal Res. Al/Fe	(mg/L) (mg/L) (mg/L) (mg/L) R	16.31	5.44	8.24		0.07	0.10 23.29	0.18 45.66	0.09 18.27	0.12 31.19			
	pH   Temperature	(OC) R	14.5	8.0	8.3 11.3	16.0	7.5	0.0	14.0	7.0	8.2 7.4 10.5			
NO.	Turbidity (FTU)	~ F	28.50	1.00	8.83	82.30	09.9	35.8	28.30	1.23	9.9			
	Prime Coagulant Coagulant Aid Filter Aid Metal Res. Al/Fe	(mg/L) (mg/L) (mg/L) R	0.99	3.71	9.09	1.82 85.32	28.07	0.18 51.93	51.12	0.09 16.33	0.12 31.23			
	pH Temperature	(°C)	0.6	2.0	8.3 8.0	8.5	0.4	8.0 7.3 6.3	12.0	3.0	8.2 7.7 6.5			
DEC	Turbidity (FTU) Prime Coagulant Coagulant Aid Filter Aid	(1/6w) (1/6w) (1/6w)	59.7 10.64 31.88	3.60	23.3 0.56 12.37	26.60 0.23 61.67	1.00 0.08 9.20	8.1 0.12 27.24	62.00	1.50	20.1 0.25 52.90			
	pH Temperature	(OC) R				5.0	0	8.2 7.3 1.4	5.0	0.5	8.1 7.6 2.5			

R = Raw, T = Ireated

		THORIT	THORIDITY (FTII) (2)	(2)	COAGULANT	COAG.	FILTER	METAL RES.	RES.		Hd	TEMP.
DATE		TONO!			(1)	AID	7 000	0 7 6	1,500	a d	Treat	Raw
	Raw	Set.	Filter	Ireat.	1/6w	md/L	1/5	Naw		200		
-	08.0	0.87		0.10	16.33							0
2	1.23	1.3		0.20	13.03	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1	1				0
3	13.66	1.5		0.08	34.26	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1					0
4	35.00	1.8		0.14	48.79				8 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			0
	38.00	2.0		0.13	44.34			1	!			0
9	42.00	2.1	-	0.15	36.39					1	1	0
7	22.83	2.6		0.67	53.49	1				1	1	0
8	9.30	2.8		0.21	30.43	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						0
6	3.80	1.7		0.20	27.49	1 1 1 1 1 2 1				,	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0
100	2.60	1.4		0.16	20.44	1 1 1 1 1 1 1 1				1		0
=======================================	1.90	1.2		0.15	18.91	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					1 3 1 1 1 1	0
12	1.50	1:1		0.12	16.25	1 1 1 1 1 1 1 1						0
13	21.90	2.1		0.12	28.10	1 1 1 1 1 1 1 1					1	0
14	12.60	1.4		0.12	36.53	1 1 1 1 1 1 1 1						0
15	11.50	1.8		0.37	38.16			1				0

<sup>(1)</sup> Note: \* denotes polyahuminum chlorida (PAC) + denotes dry ahum all other entries liquid ahum

<sup>(2)</sup> The unit of measurement at Grimsby is NTU.

	TURBI	TURBIDITY (FTU)		COAGULANT (1)	COAG. A10	FILTER   AID	METAL RES. Al/Fe (mg/L)	RES. (mg/L)	_	표	TEMP.
Raw	Set.	Filter	Treat.	1/6w	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
4.45	2.1		0.33	27.35	1			1			0
2.30	1.4	1	0.27	24.64				1	1		0
9.27	3.3		0.19	24.37			-		1		0
12.58	2.9		0.24	49.66					1 1 1		0
22.58	1.6	1	0.17	46.57			1	1	1		0
21.33	2.9		0.45	47.92	1	-					1.0
18.33	3.9		0.47	31.48/30.54					1 2 1 1		1.5
9.80	2.7		0.28	31.29/51.55				-	1		0
10.40	2.7		0.41	43.15/46.76					1	-	0
22.00	3.8		0.45	9.92/38.55					1	-	1.0
21.30	4.0		0.51	11.08/43.49	1						0.5-
35.70	4.6		0.60	32.32/14.92	1					1	0
12.90	2.9	-	0.23	*16.24							0
7.30	2.9		0.18	*13.54	1						0
5.10	3.2		0.14	*17.04							0
2.8	1.8		0.14	* 7.13							0

<sup>(1)</sup> Note: \* denotes polyaluminum chloride (PAC) + denotes dry alum Il other entries liquid alum

8.71 13.03 13.03 13.03 13.04 10.08 10.99 10.99 10.35 10.35 10.35 10.36 10.10		TURE		TURBIDITY (FTU)	1 1	COAGULANT   PAC	COAG. ATD	FILTER	METAL RES. Al/Fe (mg/L)	RES. (mg/L)	1 1	됩	TEMP.
5.49 13.03 13.04 6.39 10.08 10.09 11.35 8.56 8.56 8.56 11.10	Raw Set. Filter	Filter	H	i I	Treat.	mg/L	mg/L	mg/L	Kaw	Ireat.	Kaw	lreat.	Kaw
13.01 13.01 13.01 10.08 10.08 10.99 11.35 8.58 8.58	9.00 2.6	<del> </del>		1	0.14	5.49	1			1			0
13.03 6.39 13.10 10.08 10.99 13.35 13.35 13.35 13.35 8.56 8.96 11.10	13.90 3.5		0	0	0.13	8.71	1	-	1	•		1	0
13.01 13.01 10.08 10.99 10.35 8.58 8.58 8.58 11.10	20.50 3.4 0		0	0	0.15	13.03							0
6.39 13.01 10.08 10.99 13.35 13.45 13.45 13.45 13.45 13.45 13.45 13.45 13.40	18.50 3.7 0		0	0	0.11	13.01	1 1 1 1 1 1				-	1	0
13.10 10.08 10.99 13.35 8.58 8.58 8.58 11.10	15.10 5.4 0.		0	0	0.17	6.39	1	1				1	0
13.01 10.08 10.99 13.35 8.56 8.96 11.10	37.70 5.0 0.		0	0.	0.14	13.10							0
10.08 13.35 13.35 8.58 8.58 9.75 11.10	38.60   6.3   0.	1	0.	0.	15	13.01							0
9.75 11.10 11.10			0.	0.	15	10.08							0
8.58 8.96 9.75 11.10	27.70 5.2 0.		0	0	61	10.99							0
8.58 8.96 9.75 III.10	22.50 4.9 0.		0.	0.	16	13,35		1					0
9.75	25.00 7.2 0.		0	0	12	8.58		1				1	0
9.75 11.10 8.23	24.70 8.8 0		0	0	16	96.8					1		0
11.10 8.23	17.67 5.0 0		0	0	0.31	9.75						1	0
8.23	11.92   4.1   0		0	0	0.30	11.10							0
	11.42 4.9 0	-	0	0	18	8.23				_			0

DATE		TURBI	TURBIDITY (FTU)		COAGULANT PAC	COAG.	FILTER	METAL RES. Al/Fe (mq/L)	RES.	푭		(oc)
	Raw	Set.	Filter	Treat.	J/Gw	mg/L	1/6m	Raw	Treat.	Raw	Treat.	Raw
16	10.25	3.8		0.32	7.54							0
17	15.83	3.3	1	0.23	10.64							0
18	18.67	4.2	1	0.19	11.48	1	1 1			<del>-</del>		0
19	7.73	4.4		0.18	7.81	1				·	-	0
50	6.70	4.6		0.17	8.45	1						0
21	17.50			0.14	8.86	1						0
22	26.30			0.19	11.42	1						0
23	22.70			0.14	9.72	1 1 2 3 1	1					0
24	18.50	i		0.13	11.01	· 1	1			. – <del>i</del>		0
25	27.50	i		0.17	7.57	1	1			· - <del> </del>		0
26	19.50			0.17	11.75	1				·- <del>-</del>		0
27	17.00			0.19	10.41							0
28	7.23	4.4		0.24	5.62							0
29				1		1						
30				1	1	1	1					
31												

## TABLE 2.1: PARTICULATE REMOVAL PROFILE

A10 A10 A1/Fe (mg/L) Pm Treat. Raw Treat. B						COAGULANT	COAG.	FILTER	METAL	RES.			TEMP.
Raw         Set.         Filter         Treat.         mg/l         mg/l         Raw         Treat.         Raw         Treat.           3.42         4.0         0.17         3.94         6.17         4.60         6.17         6.18         6.19 <t< th=""><th>DATE</th><th></th><th>TURBI</th><th>DITY (FTU)</th><th>_</th><th>PAC</th><th>AID</th><th>I AID</th><th>Al/Fe</th><th>(mg/L)</th><th>ā —</th><th>-</th><th>(၁၀)</th></t<>	DATE		TURBI	DITY (FTU)	_	PAC	AID	I AID	Al/Fe	(mg/L)	ā —	-	(၁၀)
3.42         4.0         0.15         3.94           3.42         3.0         0.15         4.50           2.67         2.6         0.15         4.50           2.98         2.8         0.14         2.89           2.02         2.1         0.24         2.03           48.30         6.5         0.24         9.75           10.40         5.5         0.23         7.85           4.97         3.8         0.22         6.97           21.17         5.4         0.39         7.24           40.50         3.6         0.17         16.60           40.50         5.3         0.26         16.09           22.10         4.4.4         0.32         13.72	-	Raw	Set.	Filter	Treat.	1/6m	mg/L	1/6m	Raw	Treat.	$\vdash$	Treat.	Raw
3,42         3.0         0.15         4.01           2,58         2.8         0.14         2.89           2,02         2.1         0.24         2.03           24,20         4.1         0.24         2.03           48,30         6.5         0.24         9.75           10,40         5.5         0.23         7.85           15,33         8.7         0.23         7.24           21,17         5.4         0.39         7.24           23,00         13.6         0.17         16.60           29,50         5.3         0.26         16.09           21,17         4.4         0.32         13.27		3.42	4.0		0.17	3.94				1			
2.67         2.6         0.15         4.50           2.98         2.89         8.84           2.02         2.1         0.24         2.03           48.30         6.5         0.24         9.75           10.40         5.5         0.23         7.85           15.31         8.7         6.97           21.17         5.4         0.39         7.24           23.00         13.6         0.17         16.60           40.50         5.3         0.26         16.09           21.17         4.4         0.32         13.27	2	3.42	3.0		0.15	4.01			1	. !	·		
2.98         2.8         0.14         2.89           2.02         2.1         0.24         2.03           48.30         6.5         0.24         9.75           10.40         5.5         0.23         7.85           15.33         8.7         0.22         6.97           21.17         5.4         0.39         7.24           40.50         3.6         0.17         16.60           29.50         5.3         0.26         16.09           21.17         4.4         0.32         13.72	3	2.67	2.6		0.15	4.50		1	1	1			
2.02         2.1         0.24         2.03           24.20         4.1         0.26         6.68           10.40         6.5         0.24         9.75           10.40         5.5         0.23         7.85           4.97         3.8         0.23         5.14           15.33         8.7         0.22         6.97           21.17         5.4         0.39         7.24           23.00         13.6         0.17         16.60           40.50         5.3         0.26         16.09           21.17         4.4         0.32         13.27	4	2.98	2.8	1	0.14	2.89			1			1	1
24.20         4.1         0.26         6.68           48.30         6.5         0.24         9.75           10.40         5.5         0.23         7.85           15.31         8.7         0.23         5.14           15.33         8.7         0.22         6.97           21.17         5.4         0.39         7.24           40.50         3.6         0.17         16.60           29.50         5.3         0.26         16.09           21.17         4.4         0.32         13.27	5	2.02	2.1		0.24	2.03			1				1 1
48.30         6.5         0.24         9.75            10.40         5.5         0.23         7.85            4.97         3.8         0.22         6.97            21.17         5.4         0.39         7.24            40.50         3.6         0.17         16.60           29.50         5.3         0.26         16.09           21.17         4.4         0.32         13.27	9	24.20	4.1	1	0.26	6.68							0
10.40         5.5         0.23         7.85           4.97         3.8         0.23         5.14           15.33         8.7         0.22         6.97           21.17         5.4         0.39         7.24           23.00         13.6         0.50         8.84           40.50         3.6         0.17         16.60           29.50         5.3         0.26         16.09           21.17         4.4         0.32         13.27	7	48.30	6.5	1	0.24	9.75				1		1	0
15.33     8.7     0.23       15.33     8.7     0.22       21.17     5.4     0.39       23.00     13.6     0.17       40.50     3.6     0.17       29.50     5.3     0.26       21.17     4.4     0.32	8	10.40	5.5	1	0.23	7.85						1	0
15.33     8.7     0.22       21.17     5.4     0.39       23.00     13.6     0.50       40.50     3.6     0.17       29.50     5.3     0.26       21.17     4.4     0.32	6	4.97	<u>!</u>		0.23	5.14							0
21.17     5.4     0.39       23.00     13.6     0.50       40.50     3.6     0.17       29.50     5.3     0.26       21.17     4.4     0.32	10	15.33	8.7	! ! ! !	0.22	6.97				1			0
23.00     13.6     0.50       40.50     3.6     0.17       29.50     5.3     0.26       21.17     4.4     0.32	==	21.17	<u>!</u>	1	0.39	7.24				1		1	0
40.50         3.6         0.17           29.50         5.3         0.26           21.17         4.4         0.32	12	23.00	l	1	0.50	8.84							0
29.50 5.3 0.26 21.17 4.4 0.32	13	40.50	<u> </u>	1	0.17	16.60			1	1			0
21.17 4.4 0.32	14	29.50			0.26	16.09							0
	15	21.17	1		0.32	13.27				. <b>_</b> -			0

					COAGIII ANT	COAG.	FILTER	METAL RES	RES.			TEMP.
DATE		TURBI	TURBIDITY (FTU)	_	PAC	AID	AID	A1/Fe	(mg/L)		E.	(00)
	Raw	Set.	Filter	Treat.	7/5w	mg/L	1/6w	Raw	reat.	Raw	Treat.	Raw
16	14 83	-		72.0	13.17				- <b>-</b>			0
		-				1 1 1 1 1 1 1 1 1		1 1 1 1 1 1				
11	7.82	4.1		0.26	26.13	1			-	-		0
81	10.97	4.3		0.22	10.30	1		-		1		0
19	21.29	6.1		0.34	10.96					1	-	1.5
20	19.00	4.8		0.12	10.83			1	1		-	1.5
21	10.30	5.8		0.15	9.29			1				0
22	7.60	4.7		0.15	7.84							1.0
23	4.20	4.4		0.27	65.9				1		1	2.0
24	4.70	3.1		0.12	7.09					1		1.0
25	8.00	4.1		0.16	7.11							1.5
26		2.3		0.19	3.74					-		2.5
27		1.3		0.12	4.41	1					-	3.0
28		į		0.13	3.62	1				-		3.0
29	1.02	i		0.13	2.61			-	1			3.0
30	1.03	1.0		0.15	2.77	1	1			-		3.0
31	0.86	6.0		60.0	3.32							4.5

TABLE 2.1: PARTICULATE REMOVAL PROFILE

APRIL 1986 .

					COAGULANT	COAG.	FILTER	METAL	RES.	Ha	=	TEMP.
LIVE		TURBIL	TURBIDITY (FTU)		PAC	AID	AID	A1/Fe	(mg/L)	- 1		
NA IF	28.5	, tet	Filter	Treat.	mg/L	1/6m	1/Bm	Raw	Treat.	Raw	lreat.	Kaw
						L						5.0
-	1.01	6.0		0.15	2.02	-	-				1	
2	5.21	2.5		0.23	5.03				. 1			0.0
	20.70	<u> </u>		0.13	6.54		1		1			5.0
4	18.50	7.1		0.36	5.25		1				1	5.0
5	69.50	3.8	1	0.13	11.17							0.0
9	40.00	4.2		0.11	11.87			1				0.0
7	27.00	4.6	-	0.12	10.85						1	0.0
	17.80	5.0	-	0.11	8.58						1 1 1	0.0
6	12.40	5.7		0.14	5.43							2.5
101	9.40	3.7		0.14	8.46			1				1
=	3.32	2.5		0.21	3.93							0.0
12	3.20	2.5	-	0.22	4.49	; ; ;					1	
	2.63	3 2.2	<u> </u>	0.28	2.30			<u> </u>	-			3-5
14	3.78	3 2.7	<u> </u>	0.23	4.55					-		u-r
15	4.98	2.5	1	0.15	5.65							

DATE		TURBIL	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES. Al/Fe (mq/L)	(mq/L)	Hd		(oc)
	Raw	Set.	Filter	Treat.	J/6m	mg/L	1/6w	Raw	Treat.	Raw	Treat.	Kaw
91	13.78	3.2		0.14	7.20							4.0
17	65.70	23.7		9.54	14.88							5.0
18	10.10	4.3		0.59	11.85			-				5.0
19	8.02	3.7	1	0.17	9.20			-		- †		10.01
20	3.15	3.3		0.14	4.31							5.0
21	5.53	4.5		0.21	5.72		1		-			5.0
22	13.42	5.2		0.10	4.87				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			5.0
23	8.78	4.1		0.10	8.92							5.0
24	7.65		1	0.33	99.6					- <del>-</del>		5.5
25	5.02	4.4		0.22	4.64				1	-		5.0
- 56	3.87	3.3		0.48	6.77	1						5.0
-27	2.52	2.2		0.23	5.24					- <del>-</del> -		5.0
28	2.43	2.0		0.21	4.14				1			8.0
29	1.98	1.0		0.41	3.60	1						6.5
30	2.03	1.6		0.28	4.64							6.5
E .												

#### MAY 1986

			10000		COAGULANT	COAG.	FILTER	METAL	METAL RES.	L	Ho	TEMP.
DATE		IUKBI	IUKBIDITY (FIU)	_	PAC	AID	AID	AI/Fe	(mg/L)	- 1		100
-	Raw	Set.	Filter	Treat.	mg/L	mg/L	1/6m	Raw	Treat.	Kak	lreat.	Kaw
_	4.60	1.5		0.22	4.89					       	1	6.5
2	5.30	2.3		0.18	5.13	1 1 1 1 1 1 1 1					1	6.5
3	3.40	2.3		0.18	5.08							5.5
4	2.10	1.4		0.18	4.44				1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		5.5
	2.00	1.3		0.21	4.36					1		5.5
9	1.40	1.1	1	0.13	3.34			1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			6.5
	1.50	1.0		0.13	2.80					1		7.0
9	1.39	6.0		0.13	1.98	1 1 1 1 1 1 1					1	7.0
6	1.70	1.0		0.24	2.65							6.5
10	1.40	1.0	1	0.11	2.60		1			1		7.0
=	1.20	6.0		0.18	2.59	1					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	7.0
12	9.60	2.4		0.11	3.69	1			1 1 1 2 3	-	1	9.0
13	4.20	2.4		0.12	3.61			1	 			9.0
14	7.50	3.8		0.11	5.29					-	1	10.0
15	2.70	2.0	1	0.14	3.42							0.6

ABLE	ABLE 2.1 (cont'd.)	,	MAY 1986								Pag	Page 2 of 2
DATE		TURBIC	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAI Al/Fe	METAL RES. Al/Fe (mg/L)	1	퓚	(0C)
	Raw	Set.	Filter	Treat.	1/6w	mg/L	1/6m	Raw	Treat.	Raw	Treat.	Raw
16	2.10	1.6		0.30	2.87					1		8.0
17	1.70	1.3		0.25	3.05						1	9.0
18	1.20	1.0		0.17	3.26							8.0
19	-30.43.			1.42	3.37	1			-	-		8.0
20	-42.43.	10.3		2.50	23.69	1				-		9.0
21	3.00-	85,		0,22	12,62	1				-		9.0
22	1.67			0.14	6.05	1		1		-	-	9.5
23		4		0.0	4.41							9.0
24				60.0	3.88					:		10.0
25	2 18	1 7		0.28	3.50						1	10.0
26		9.1		0.36	3.99			1				12.0
27	1 57			0.17	3.96		1					10.0
28	1.57			9.17	4.87			1	-			10.0
53	1.20			0.17	3.82				-			12.5
30	1,20			0.29	4.20						- !	15.0
31	2.97			0.28	7.00							15.5

## L PROFILE JUNE 1986 .

					COACIII ANT	COAG	FILTER	MFTAL	RFS.		:	TEMP.
77.40		TURBIC	TURBIDITY (FTU)	_	PAC	AID	AIG	Al/Fe	(mg/L)		표	(oc)
DA IE	Raw	Set.	Filter	Treat.	mg/L	mg/L	1/5w	Raw	Treat.	Raw	Treat.	Raw
-	1.82	1.4		86.0	7.25				1			8.0
2	5.50	1.8		0.07	5.65	1		3	. 1			10.0
3	2.60	1.7		0.18	4.72				1	1		11.5
4	1.40	1.2		0.25	3.99			-				11.0
	3.00	1.3		0.30	5.73							12.0
9	2.80	1.7		0.18	5.27							11.0
7	2.40	1.3		0.13	4.40			1				11.0
8	2.40	4.3		0.17	4.21				1			12.0
6	1.60	1.6	<u> </u>	0.13	4.32					1		12.5
10	1.20	6.0	1	0.18	3.66		1		-			12.0
=	1.30	6.0	1	0.26	4.08					-		12.0
12	5.70	2.6	1	0.14	4.95							12.0
13	06.6	3.4	1	0.14	6.22							12.5
14	2.80	2.2		0.14	6.42							13.0
15	1.20	1.3	1	0.11	5.16							13.0
	_	_										

					COAGULANT	COAG.	FILTER	METAL RES.	RES.	•	1	TEND.
DATE		TURBI	TURBIBITY (FTU)	_	PAC	AID	I AID	Al/Fe	(mg/L)		nd	(oc)
_	Raw	Set.	Filter	Treat.	mg/L	mg/L	1/6m	Raw	Treat.	Raw	Treat.	Raw
16	1.50	1.6		0.15	8.51							12.0
17	2.00	1.6		0.10	3.34					1		13.0
18	2.10	1.5		0.11	5.92							13.0
19	1.42	1.1		0.13	5.86					1		13.0
	1.18	1.1		0.15	4.61							13.0
21	1.08	1.0		0.15	4.33	1	,					12.5
22	1.02	1.0		0.16	4.01	1			i i i			11.0
23	0.95	1.1		0.20	4.10			1	1			11.0
24	1.43	1.3		0.12	4.70				1	1		14.5
25	3.58	1.9		0.15	6.41							14.0
26	1.00	1.0		0.07	5.39					1	-	13.5
27	1.00	0.8		0.10	4.36				1	1		10.0
82	1.10	6.0		0.12	3.85			1	1	1		11.0
62	1.00	6.0		0.10	3.95					1 1	-	14.0
30	1.50	1.2		0.09	5.51	1	-	1				14.0
31												

DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL Al/Fe	METAL RES. Al/Fe (mq/L)	a.	Hd	TEMP.
	Raw	Set.	Filter	Treat.	mg/L	mg/L	1/6w	Raw	Treat.	Raw	Treat.	Raw
-	1.00	3.9		0.14	5.33							15.0
2	1.40	3.5		0.09	4.75	1 1 1 1 1 1 1			-			15.0
3	2.30	2.7	1	0.11	6.39	   1   1   1   1   1   1   1						15.5
4	1.70	1.8	1	0.11	5.13	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						15.0
	1.20	2.2	1	0.16	4.62	1 1 1 1 1 1 1 1 1						13.0
9	1.10	2.2	1	0.18	4.37						1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	14.5
	1.30	1.6		0.21	4.51						1	15.5
80	1.30	1.6		0.17	4.32							14.0
6	1.40	1.2		0.13	4.84						1	16.0
01	1.80	1.9		0.10	4.46	1 1 1			1			17.5
=	7.30	2.1		0.15	7.66				1			17.0
12	12.20	2.2		0.08	11.00				1			9.0
13	5.80	2.4		0.07	11.88							14.5
14	5.10	1.6		60.0	9.21						1	15.5
15	2.40	1.4		0.10	7.28							16.5

<del>-</del>			Tagar	(IIIA) VIIO		COAGULANT	COAG.	FILTER	METAL RES	RES.		1	TEMP.
Raw         Set.         Filter         Treat         mg/L           1.80         3.8         0.13         5.93           2.20         2.1         0.16         5.03           2.13         3.0         0.10         6.73           3.08         2.8         0.10         6.73           2.63         2.2         0.19         6.21           2.05         1.3         0.09         6.26           1.53         1.1         0.09         6.02           1.80         1.1         0.09         6.02           2.00         1.1         0.11         4.78           2.50         1.1         0.12         6.79           2.50         1.1         0.12         6.79           2.50         1.1         0.12         6.79           2.50         1.1         0.12         6.35           2.70         2.2         0.12         5.33           2.70         2.2         0.12         5.33           4.77         1.4         0.17         6.35           8.90         1.0         0.09         9.75	)AIE		IONDI	(110)		PAC	AID	O V	A1/Fe	A1/Fe (mg/L)	- 1		(00)
1.80     3.8     0.13       2.20     2.1     3.0     0.10       3.08     2.8     0.12       2.63     2.2     0.19       3.11     1.8     0.16       2.05     1.3     0.09       1.53     1.1     0.09       1.80     1.1     0.12       2.00     1.1     0.12       2.50     1.1     0.24       2.70     2.2     0.15       4.77     1.4     0.15       6.80     1.0     0.10       6.80     1.0     0.09	1	Raw	Set.	Filter		1/6w	mg/L	1/Em	Raw	Treat.	Raw	Treat.	Raw
2.20         2.1         0.16           2.13         3.0         0.10           3.08         2.8         0.12           2.63         2.2         0.19           3.11         1.8         0.16           2.05         1.3         0.09           1.80         1.1         0.09           1.80         1.1         0.12           2.00         1.1         0.24           2.50         1.1         0.15           2.70         2.2         0.15           4.77         1.4         0.17           8.90         1.0         0.09	16	1.80	3.8		0.13	5.93							17.0
2.13     3.0     0.10       3.08     2.8     0.12       2.63     2.2     0.19       2.05     1.3     0.09       1.53     1.1     0.09       1.80     1.1     0.11       2.00     1.1     0.12       2.50     1.1     0.24       2.70     2.2     0.15       4.77     1.4     0.17       8.90     1.0     0.10       6.80     1.0     0.09	=	2.20	2.1		0.16	5.03	_						16.0
3.08     2.8     0.12       2.63     2.2     0.19       3.11     1.8     0.16       1.53     1.1     0.09       1.80     1.1     0.11       2.00     1.1     0.12       2.50     1.1     0.24       2.60     1.1     0.15       2.70     2.2     0.15       4.77     1.4     0.17       8.90     1.0     0.10       6.80     1.0     0.09		2.13	3.0		0.10	6.73	_						14.5
2.63     2.2     0.19       3.11     1.8     0.16       2.05     1.3     0.09       1.80     1.1     0.09       2.00     1.1     0.12       2.50     1.1     0.24       2.60     1.1     0.15       2.70     2.2     0.15       4.77     1.4     0.17       8.90     1.0     0.09	19	3.08	2.8		0.12	7.91		1	1 1			1	13.5
3.11     1.8     0.16       2.05     1.3     0.09       1.53     1.1     0.09       1.80     1.1     0.11       2.00     1.1     0.12       2.50     1.1     0.24       2.70     2.2     0.15       4.77     1.4     0.17       8.90     1.0     0.10       6.80     1.0     0.09	20	2.63	2.2		0.19	6.21	1	1		1		1	15.5
2.05     1.3     0.09       1.80     1.1     0.09       1.80     1.1     0.11       2.00     1.1     0.12       2.50     1.1     0.24       2.60     1.1     0.15       2.70     2.2     0.15       4.77     1.4     0.17       8.90     1.0     0.10       6.80     1.0     0.09	21	3.11	1.8		0.16	6.51					1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	19.5
1.53         1.1         0.09           1.80         1.1         0.11           2.00         1.1         0.12           2.50         1.1         0.24           2.70         2.2         0.15           4.77         1.4         0.17           8.90         1.0         0.019           6.80         1.0         0.09	22	2.05	1.3		60.0	6.26							18.5
1.80         1.1         0.11           2.00         1.1         0.24           2.50         1.1         0.24           2.70         2.2         0.15           4.77         1.4         0.17           8.90         1.0         0.10           6.80         1.0         0.09	23	1.53	1.1		60.0	6.02							18.0
2.00     1.1     0.12       2.50     1.1     0.24       2.60     1.1     0.15       2.70     2.2     0.12       4.77     1.4     0.17       8.90     1.0     0.11       6.80     1.0     0.09	24	1.80	1.1		0.11	4.78							18.5
2.50     1.1     0.24       2.60     1.1     0.15       4.77     1.4     0.12       8.90     1.0     0.11       6.80     1.0     0.09	25	2.00	1.1		0.12	6.79						1	15.5
2.60     1.1     0.15       2.70     2.2     0.12       4.77     1.4     0.17       8.90     1.0     0.11       6.80     1.0     0.09	56	2.50	1.1		0.24	6.57							16.0
2.70         2.2         0.12           4.77         1.4         0.17           8.90         1.0         0.11           6.80         1.0         0.09	27	2.60	1.1		0.15	5.33				-			19.0
8.90 1.0 0.17 6.80 1.0 0.09	28	2.70	2.2		0.12	5.56							15.0
8.90 1.0 0.11 6.80 1.0 0.09	59	4.77	1.4		0.17	6.35							20.0
6.80 1.0 0.09	30	8.90	1.0		0.11	10.63							20.0
	31	6.80	1.0		0.09	9.75		1					20.0

					COAGIII ANT	COAG.	FILTER	METAL	RES.	:		d.
OATE		TURBIC	TURBIDITY (FTU)		PAC	A10	AIO	Al/Fe	Al/Fe (mg/L)	Hd		(00)
	Raw	Set.	Filter	Treat.	mg/L	1/5w	1/bw	Raw	Treat.	Raw Tre	Treat. Raw	- -
	3.80	1.9		0.07	6.32						20.0	
~	3.80	2.3		0.08	90.9				. 1		19.0	
3	3.20	3.1	1	60.0	6.47	1	1			· <u> </u>	20.0	
4	3.10	4.3		60.0	5.77		1				20.0	
- 5	2.70	2.8		0.09	4.95		1				19.5	
9	2.70	2.3	1	60.0	5.16		1	1			19.0	
7	3.30	2.5	1	0.07	5.77				1		19.0	
8	2.80	2.3	1	0.09	5.41				1		17.5	
6	2.40	2.6	1	0.11	6.12		1				19.0	
9	3.20	3.3		0.10	6.07					· — -	18.0	
=	3.30	2.5		0.10	5.26						17.5	
12	3.10	2.9		0.14	6.71				1		17.5	
13	2.50	3.2	1	0.14	4.92						17.0	
14	2.07	2.0		0.12	4.29					· – -	13.0	0
15	1.65	1.7	1	0.12	4.05						11.0	.

TEMP.	Treat. Raw	16.0	18.5	18.5	18.0	17.5	19.0	20.0	19.0	18.5	18.0	18.5	18.0	17.0	16.0	16.0	
đ	Raw Tr		1														
METAL RES.	Treat.																1111111
I MET	Raw																111111
FILTER	J/bw																
C0AG. A10	mg/L														1 1 1 1 1 1 1 1 1		
COAGULANT	mg/L	5.11	3.82	4.58	8.03	8.29	6.72	10.67	11.69	10.70	10.43	6.51	6.41	6.80	5.71	4.43	
	Treat.	0.13	0.13	0.15	0.16	0.11	60.0	0.11	0.07	90.0	0.07	0.11	0.19	0.08	60.0	0.12	
TURBIDITY (FTU)	Filter		† † † † †														1 1 1 1 1 1 1
TURBIL	Set.	1.8	1.6	2.2	2.1	2.8	2.6	2.1	2.0	1.9	1.8	2.1	2.1	2.5	2.5	2.8	
	Raw	1.85	1.92	2.20	4.77	3.80	2.90	20.70	11.60	11.00	8.60	2.90	4.55	6.70	4.40	2.50	
DATE		91	17	18	19	20	21	22	23	24	25	26	27	28	29	30	111111

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								4		
DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG. ATD	FILTER	Al/Fe (mg/L)	픱	(GE).
	Raw	Set.	Filter	Treat.	1/5m	mg/L	mg/l	Raw Treat.	Raw Treat.	Кам
-	2.00	3,3		0.19	4.82				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	16.0
2	1.70	2.3		0.17	6.03				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	16.5
3	3.20	2.8	1	0.11	5.53		1			16.5
4	3.20	1.9	1	0.08	5.73				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	16.5
	2.70	1.6	1	0.08	5.07				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	16.0
9	2.00	1.6		0.12	5.49				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	16.0
7	2.70	1.7		0.12	5.05				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	16.0
8	2.40	2.6		0.12	5.56				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	15.5
6	1.60	2.4		0.22	5.44					15.0
01	1.30	2.0	1	0.10	4.91					14.5
=	1.80	1.9		0.11	4.58				1	13.5
12	1.40	2.1	1	0.09	4.58					13.5
13	1.30	2.1	1	0.07	3.40					12.5
14	1.50	2.8		60.0	5.39					11.5
15	3.90	3.1		0.10	3.92	 				14.0
_									-	

					COAGULANT	COAG.	FILTER	METAL	RES.			TENP.
DATE	_	IUKBI	IUKBIDIIY (FIU)	_	PAC	AID	I AID I	Al/Fe (mg/L	(mg/L)	ā.		(oc)
	Raw	Set.	Filter	Treat.	1/6w	mg/t	1/5w	Raw	Treat.	Raw	Treat.	Raw
91	10.90	1.4		0.07	96.6							11.0
17	5.20	1.4		0.08	6.59				. 1			11.5
18	3.50	1.2		0.08	6.03							12.0
19	2.70	1.3		0.08	5.58							12.0
50	4.50	1.1		0.07	6.57	) 1 1 1 1 1						13.0
21	6.30	1.3		90.0	6.94	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						11.0
22	4.20	1.7		0.08	6.74							12.0
23	4.80	2.3		0.07	7.05	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		:		· — -		11.5
24	3.10	2.5		0.08	7.07						1	12.0
25	2.20	1.9		0.07	6.38	1						12.0
26	2.20	1.8		0.10	5.68	1 1 1 1 1 1	1					13.0
27	26.20	2.1		0.07	7.77							13.0
28	14.20	2.6		0.08	8.47	1						13.0
29	4.90	1.5		0.07	6.01	)   				-		14.0
30	4.10	1.8		0.11	5.27				1		1	14.0
31												

OCTOBER 1986

DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	Al/Fe (mg/l	RES.		표	TEMP.
	Raw	Set.	Filter	Treat.	J/Eu	J/bw	1/5w	Raw Treat	Treat.	Raw	Treat.	Raw
-	8.30	5.3	1	0.36	6.13	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						14.5
2	8.60	5.4	1	0.55	11.10	           						14.5
6	6.00	3.4		0.18	9.95							14.0
4	11.10	3.3		0.16	8.50							14.5
5	13.80	2.7		0.0	10.72	=						14.0
9	15.30	2.2		0.07	12.58			1			1	13.5
_	6.40	3.8		0.13	8.29	1					1	12.5
æ	5.20	3.3		0.52	11.29		·					12.0
6	11.85	1.7		0.12	16.31		<u>-</u>				1	12.5
9	16.58	1.9		0.08	10.78						1	11.0
=	8.22	2.2		0.08	9.13							11.5
12	2.88	2.1		0.15	8.19	_					1	11.5
13	2.40	1.8		0.07	7.87		1					11.5
4	2.37	1.8		90.0	5.44		1				1	12.0
15	3.05	2.1		0.08	6.31	1		<del>-</del>	<u> </u>			11.0
-								-	-			-

		T ddirk	Willy Will		COAGULANT	COAG.	FILTER	METAL	METAL RES.		Ha	TEMP.
_		INKRI	INKBIDITY (FID)	_	PAC	AID	AID	AI/re	(mg/L)	- 1		(20)
	Raw	Set.	Filter	Treat.	mg/L	mg/L	J/6m	Raw	Ireat.	Kav	lreat.	Kaw
	98				7 13							10.5
_	3.20-	7.7							1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
	7.90	1.8		0.08	8.46	1		-	1	-		5.01
	4.60	1.6		60.0	9.84	1						10.0
			-	21.0	7.26							10.0
						1 1 1 1 1 1			1			10.0
	-1:70-	1:4		0.14	19.9	1 1 1 1 1 1 1 1 1 1			1	-		
	1.90-	1:4		0.10	6.11	1		-	1			10.5
	1.50	1.6		0.10	5.63	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			1			10.5
<del>-</del> -	90 (			60.0	8.16				1	1		10.5
24				80 0	7.54	1						10.5
					- 00			1	1 1 1 1 1			8.0
7	3.20-	2,0		17577					1	-		0 01
	3.40	2.6		0.07	7.28	1			1			0.01
	4.20	2.5		0.08	6.17	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				-	1	10.0
28	4.00	<u>.</u>	-	0.08	6.17				1			10.0
z	06 0	!		60.0	6.88	1						10.0
 	- S	<u> </u>		0.07	5.90	1 1 1 1 1 1 1 1	1					10.01
		1_		0 11	7.44				1			9.0
- -	OT -	1.7	_									

DATE		TURBI	TURBIDITY (FTU)		COAGULANT PAC	COAG.	FILTER	METAL RES. Al/Fe (mg/L	RES. (mg/L)	d	퓝	TEMP.
	Raw	Set.	Filter.	Treat.	1/6ш	mg/L	1/5m	Raw	Raw Treat.	Raw	Treat.	Raw
	1.90	1.3		90.0	6.65							8.5
2	1.40	1.4		0.07	4.96			1 1	. !			9.0
e	3.40	2.5		0.12	7.24						1	8.0
4	3.50	1.7		0.08	8.36				i i i i			8.0
S	9.80	2.0		0.17	8.52				 :	<del>:</del>	1	7.0
9	4.52	2.4		0.11	7.82						3	7.0
	2.73	2.0		0.14	8.40							7.0
8	1.82	1.4		90.0	5.65						1	7.0
6	5.57	2.0		0.09	8.39	,						7.0
10	3.77	2.1		0.08	7.17			1			1	6.5
=	3.92	2.9		0.14	6.37				1		1	5.0
12	3.38	2.4		0.11	6.27						-	5.0
E .	3.10	1.9		0.12	7.87							5.0
4	1.40	1.2		90.0	6.52							5.0
15	1.17	1.0		0.10	8.25							
					-							

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	1	_,-			<del>-</del> -			- <del>-</del>		<del></del>		<del></del>						,
TEMP.	(00)	Kaw		4.5	4.0	3.5	3.0	2.0	2.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
1	5	Treat.				-	- !											
	- 1	Raw	1	) 1 1 1 1			-		-			1						
METAL RES.	(mg/L)	Treat.	1	1	1								1		1	1	1	
METAL	A1/Fe	Raw	, , ,		1												1	
FILTER	AID	mg/L	1			1					1							
COAG.	AID	mg/L	1			1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1	1		1	1	1		1	1		
COAGULANT	PAC	1/6w	3.71	4.77	6.55	14.38	12.02	13.41	12.24	16.34	10.30	10.83	16.00	8.45	16.12	8.94	10.20	
	_	Treat.	60.0	0.08	0.00	0.08	0.07	0.08	90.0	0.12	0.08	0.17	0.41	66.0	0.10	0.11	0.00	
	TURBIDITY (FTU)	Filter											1					
	TURBIE	Set.	1.0	6.0	1.1	3.8	2.6	3.3	3.8	3.1	2.6	5.1	5.4	3.4	6.5	4.0	3.3	
		Raw	1.00	1.10	10.80	28.50	17.50	24.60	19.00	10.00	9.70	12.80	21.00	27.40	8.80	7.50	13.70	
	DATE	_	16	17	18	- 61	20	21	22	23	24	25	26		28	29	30	33

TABLE 2.1: PARTICULATE REMOVAL PROFILE

DECEMBER 1986

					1110	0400	1	4.477	444			
DATE		TURBI	TURBIDITY (FTU)		CUAGULANI	CUAG.	A A 10	Al/Fe (mg/L	. KES (mg/L) .	_	рH	TEMP.
	Raw	Set.	Filter	Treat.	mg/L	1/6w	J/Ew	Raw	Treat.	Raw	Treat.	Raw
-	19.50			80.0	12.80							
2	28.00			0.16	17.33	1 1 1 1 1 1 1	1	1	1	1		1
m	30.70	! ! ! !		0.11	20.55	1 2 6 2 8 6 1 1	1	1	1	1	: : : : : :	1
4	41.00		1	0.14	11.44	1 1 1 1 2 1 2 1	1	1	1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1	1
- 2	19.83	1	1	0.15	8.34						5 1 8 3 9	1
9	15.63			0.18	10.79		1				1	1
7	9.03			0.10	8.40			1	1	 		1
8	33.55	1	! ! ! !	0.09	9.49	) 1 1 1 1 1 1 1		1		1		1
6	33.67	1 0 1 1 1 1 1 1	1	0.0	10.13	1 5 6 1 8 8	1				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1
10	46.67	1		0.10	13.15			1				
=	28.80			0.14	11.31	1 1 1 1 1 1 1 1	! !					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
12	20.00	! ! ! ! !		0.17	12.61	1 1 2 3 4 5 1 1 1					1	 
13	16.20	1 1 1 1 1 1 1	1	0.11	9.15				1		 	
14	7.00	i i i i i		80.0	7.51	1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1		1	
15	3.60	) 		0.08	5.71	! ! ! !						
											-	-

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TEMP.	(00)	Raw																
-	-	-				<del> </del>	<del> </del> 	<del> </del> 	<del> </del>	<del>-</del>		<del> </del>	<del> </del> 	<u> </u>	<del> </del>	<u>-</u> 		-
-	Fd.	Treat.								<del> </del>			<del> </del>	- <u> </u>	<del> </del>	<u> </u>		1
L		Raw																
RES.	(mg/L)	Treat.						1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1	1	1	1		1	1		1
METAL	Al/Fe (mg/L)	Raw																1 1 1 1 1 1
FILTER	AID	mg/l.													1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1		
COAG.	AID	mg/L																
COAGULANT	PAC	mg/L	4.65	96.8	11.31	7.16	5.68	5.28	9.83	4.42	9.25	13.04	13.01	29.51	22.16	21.12	31.88	
	_	Treat.	0.18	0.38	0.13	0.15	0.23	0.0	0.39	0.12	0.25	0.0	0.12	10.64	1.02	1.31	0.22	
	TURBIDITY (FTU)	Filter			1		1											1 1 1 1 1 1 1 1 1
	TURBIG	Set.		1	1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1		 ! ! ! !		<b></b> -							
		Raw	3.70	09.9	06.9	5.60	3.90	7.70	13.50	3.60	24.5	59.7	39.2	37.27	35.8	52.0	31.7	5 0 0 0 0 0
	DATE		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

LE JANUARY 1985.

DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL Al/Fe	METAL RES.	ď	H	TEMP.
	Raw	Set.	Filter	Treat.	mg/L	1/6w	1/5w	Raw	Treat.	Raw	Treat.	Raw
-	81.50	2.2	1	0.13	86.97	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						2
2	78.30	3.2		0.12	75.42	1	1				1	2
m	64.70	2.7		0.11	72.07	1	1	1	1			1.5
4	53.70	3.3		0.18	84.43	. 1	1					1.5
5	61.50	2.4		0.29	73.19							1.0
9	18.30	1.5		0.26	45.14							1.5
7	06.30	1.9		0.20	74.87							0.5
8	72.70	5.4		0.22	74.57							0
6	34.50	2.7		0.39	73.97							0
10	36.80	3.1		76.0	83.40	) 						0
=	36.00	4.7		1.60	81.98	1 1 1 1 1 1 1						0
12	23.80	2.6		0.32	57.68							0
13	12.80	2.0		1.03	68.14	1 1 4 8 8 8	1	1				0
14	5.90	1.8		0.13	35.14							0
15	15.40	1.6		0.18	09.99	1 1 1 1 1 1 1						0

TURBIDITY (FTU)	IDITY (FT			COAGULANT	COAG. A1D	FILTER	METAL RES. Al/Fe (mg/L)	RES. (mg/L)		Hd	(0C)
Raw   Set.   Filter   Treat.	1	Treat.		1/6w	mg/L	1/6m	Raw	Treat.	Raw	Treat.	Raw
4.80   1.9   0.18	0.18	0.18		33.95				1	1		0
3.93   1.6   0.13	0.13	0.13		32.36	1						0
3.61 1.9 0.27	0.27	0.27		37.72	- I						0
3.01 1.8 0.14	0.14	0.14	<u> </u>	39.14							0
3,36 1.6	60.0	60.0		26.05	1						0
1.73 1.5 0.11	0.11	0.11		23.42				1	1		0
1.3	0.13	0.13		21.71							0
1.48 0.9 0.22	0.22	0.22		24.31							0
1.10 1.2 0.15	0.15	0.15		19.20							0
2.70 1.5 0.18	0.18	0.18		22.82			-				0
4.60 1.3 0.16	0.16	0.16		40.67					-		0
1.90 1.4 0.13	0.13	0.13		32.83						1	0
1.20 1.0 0.12	0.12	0.12		29.15					-		0
0.13	0.13	0.13		33.58							0
3.80 1.4 0.11	0.11	0.11		20.46	1						0
6.20 1.4 0.11	0.11	0.11		50.54							0

Baw         Set.         filter         Treat           8.70         1.9         0.28           9.80         1.6         0.21           10.90         1.7         0.23           6.20         2.0         0.65           8.70         1.8         0.20           18.30         2.4         0.40           22.00         2.5         0.33           11.70         2.3         0.59           3.20         1.6         0.18           11.50         2.0         0.19           41.90         2.0         0.26           24.30         2.0         0.26           24.30         2.0         0.26           24.30         2.0         0.26           24.30         2.0         0.26           24.30         2.0         0.26           24.30         0.58           34.83         4.8         0.58			212	7//E	7 7 7 5 111	. [	
1.9 1.6 1.7 2.0 2.4 2.5 2.3 2.3 2.0 2.0 2.0	48.57	mg/L	1/6w	Raw Trea	reat.	Raw Treat.	_
1.6 1.7 2.0 1.8 1.6 2.4 2.5 2.3 1.6 2.0 2.0 2.0							0
2.0 1.8 1.6 2.4 2.5 2.3 1.6 2.0 2.0 2.0	46.86				-	3	0
2.0 1.6 1.6 2.4 2.5 2.3 1.6 2.0 2.0 2.0 2.0	49.78						0
1.8 1.6 2.4 2.3 1.6 1.6 2.0 2.0 2.0	38.93						0
2.5 2.3 1.6 2.0 2.0 2.0 2.0	43.26						0
2.4	60.21						0
2.5 2.3 1.6 2.0 2.0 2.0 4.8	54.46						0
2.0	53.40						0
2.0	52.55						0
2.0	28.77						0
2.0	37.78					-	0
2.0	99.89						0
4.8	55.60	<u> </u>					0
-	76.19						0
33.50 4.4 0.40	53.54			<del></del>			0

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TEMP.	(00)	Кам	0	0	0	0	0	0	0	0.5		2		1.5	0.5			
70	ī	Treat.																
	_	Raw																
METAL RES.	(mg/L)	Treat.			-											-		
_	_	H									-				-	-	_	
FILTER	OIV	1/6w			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1		1		1	1	1	1			;	_	
COAG.	AID	mg/L				1	1							1		1		_
COAGULANT	ALLM	1/6m	51.61	50.97	47.85	49.36	47.11	47.37	32.50	45.41	66.16	58.27	66.27	69.25	58.75			
	_	Treat.	0.62	0.57	0.47	0.34	0.44	0.57	0.18	0.18	0.29	0.37	0.43	0.38	0.39		-	•
VIII TO THE TOTAL THE TOTAL TO THE TOTAL TOT	IUKBIDIIY (FIU)	Filter															_	
, adding	IUKBI	Set.	3.8	3.6	2.9	2.1	2.4	3.6	2.0	2.6	3.1	3.8	4.1	2.9	2.7	1		
	_	Raw	27.50	27.00	20.08	17.56	11.15	7.80	5.70	14.60	22.00		_21.20_	30.10	19.70			
	DATE	_	16	- 1	18	19	20	21	22	23	24	25		27	28	29	30	

#### 

Raw         Set.         Filter         Treat.         mg/l         mg/l         mg/l         Raw         Ireat.           6.00         1.9         0.18         31.02         6.00         6.00         6.01 <t< th=""><th>DATE</th><th></th><th>TURBIC</th><th>TURBIDITY (FTU)</th><th></th><th>COAGULANT A</th><th>COAG.</th><th>FILTER   AiD  </th><th>METAL Al/Fe (</th><th>METAL RES.</th><th>1 1</th><th>됩</th><th>TEMP.</th></t<>	DATE		TURBIC	TURBIDITY (FTU)		COAGULANT A	COAG.	FILTER   AiD	METAL Al/Fe (	METAL RES.	1 1	됩	TEMP.
6.00         1.9         0.18         31.82           9.00         2.1         0.13         27.35           15.70         1.7         0.14         37.73           116.20         5.5         0.31         76.01           76.50         4.5         0.64         63.98           62.50         4.9         1.03         65.61           35.20         4.1         0.80         67.27           35.30         3.8         0.56         65.32           29.20         4.3         0.34         62.26           32.00         2.9         0.23         59.01           11.30         3.0         0.33         55.25	5	Raw	Set.	Filter	Treat.	mg/L	1/6w	1/5m	Raw	Treat.	Raw	lreat.	Кам
9 00         2.1         0.13         27.35           15.70         1.7         0.14         37.73           83.80         3.3         0.24         59.70           116.20         5.5         0.31         76.01           62.50         4.9         0.64         63.98           62.50         4.9         1.03         65.61           39.80         3.8         0.61         62.11           35.30         3.8         0.60         67.27           35.30         4.1         0.80         67.27           29.20         4.3         0.34         62.26           21.30         1.8         0.23         65.08           11.30         3.0         0.32         59.01           13.00         1.8         0.30         52.63	_	6.00	1.9		0.18	31.82	1	-	-				0.5
15.70         1.7         0.14         37.73           83.80         3.3         0.24         59.70           116.20         5.5         0.31         76.01           62.50         4.5         0.64         63.98           62.50         4.9         0.61         62.11           39.80         3.8         0.61         62.11           35.20         4.1         0.80         67.27           35.30         3.8         0.56         65.32           29.20         4.3         0.34         62.26           21.30         1.8         0.23         65.08           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	2	9.00	2.1		0.13	27.35				.			0.5
83.80         3.3         0.24         59.70           116.20         5.5         0.31         76.01           76.50         4.5         0.64         63.98           62.50         4.9         1.03         65.61           35.20         4.1         0.80         67.27           35.30         3.8         0.56         65.32           29.20         4.3         0.34         62.26           31.00         2.9         0.23         65.08           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	e -	15.70	1.7	1	0.14	37.73	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1			1	0.5
116.20         5.5         0.31         76.01           76.50         4.5         0.64         63.98           62.50         4.9         1.03         65.61           39.80         3.8         0.61         62.11           35.20         4.1         0.80         67.27           29.20         4.3         0.34         62.26           21.30         1.8         0.23         65.08           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	4	83.80	3.3		0.24		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			-			0.5
76.50         4.5         0.64         63.98           62.50         4.9         1.03         65.61           39.80         3.8         0.61         62.11           35.20         4.1         0.80         67.27           35.30         3.8         0.56         65.32           29.20         4.3         0.34         62.26           21.30         1.8         0.23         65.08           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	2	116.20	5.5		0.31	76.01				-			0
62.50         4.9         1.03         65.61         62.11         62.11         62.11         62.11         62.11         62.11         62.11         62.11         62.11         62.11         62.22         62.22         62.32         62.32         62.32         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.36         62.32         62.33         62	9	76.50	4.5		0.64	63.98	1		-				0
39.80         3.8         0.61         62.11           35.20         4.1         0.80         67.27           29.20         4.3         0.56         65.32           21.30         2.9         0.23         65.08           11.30         3.0         0.32         59.01           13.00         1.8         0.30         55.25	7	62.50	4.9		1.03	65.61	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1	-			0
35.20         4.1         0.80         67.27           35.30         3.8         0.56         65.32           29.20         4.3         0.34         62.26           21.30         2.9         0.23         65.08           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	8	39.80	3.8		0.61	62.11				-			0
35.30         3.8         0.56         65.32           29.20         4.3         0.34         62.26           31.00         2.9         0.23         65.08           11.30         3.0         0.32         59.01           13.00         1.8         0.32         55.25           13.00         1.8         0.30         52.63	6	35.20	<u> </u>		0.80	67.27	1		1			1	0.5
29.20         4.3         0.34         62.26           32.00         2.9         0.23         65.08           21.30         1.8         0.23         59.01           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	01	35.30	<u> </u>		0.56	65.32	1		1				1
32.00         2.9         0.23         65.08           21.30         1.8         0.23         59.01           11.30         3.0         0.32         55.25           13.00         1.8         0.30         52.63	=	29.20	4.3		0.34	62.26	1		1	-		-	1.5
21.30     1.8     0.23     59.01       11.30     3.0     0.32     55.25       13.00     1.8     0.30     52.63	12	32.00	<u>i</u>		0.23	65.08	1		1	-			2
11.30 3.0 0.32 55.25 13.00 1.8 0.30 52.63	13	21.30	<u>!</u>		0.23	59.01		1	1			1 1 1 1 1 1 1	1.5
13.00 1.8 0.30 52.63	14	11.30	<u> </u>		0.32	55.25	1	1		-			2
	15	13.00	i 1		0.30	52.63							2

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0.22 37.24 mg/l Raw Ireat. Raw 0.22 37.24 mg/l Raw 1 mg	THREE	THRRIDITY (FTH)		COAGULANT	COAG.	FILTER	METAL RES.	RES.	품		TEMP.
0.22 0.24 0.41 0.38 0.13 0.13 0.13 0.13 0.13 0.13 0.13	Set.	Filter	Treat.	J/bw	J/Bw	mg/L	Raw	Treat.		Treat.	Raw
0.24 0.24 0.38 0.34 0.19 0.13 0.17 0.19 0.18											,
0.24 0.38 0.34 0.15 0.13 0.13 0.13 0.15 0.15	2.2		0.22	37.24	1			1 1 1 1 1 1 1	-		
0.41 0.38 0.19 0.13 0.13 0.13 0.15 0.13 0.13	1.5		0.24	34.54	1			1	- <del>-</del>		2
2.3 0.38 1.8 0.19 2.1 0.15 2.1 0.13 2.7 0.19 2.7 0.19 2.7 0.15 2.7 0.15 2.8 0.14 1.9 0.14 1.9 0.14 1.9 0.14	2.4		0.41	56.22			-				0.5
2.1 2.1 2.1 2.1 2.1 2.7 2.7 2.7 2.7 2.7 2.7 2.7 0.13 1.9 0.13 1.9 2.1 2.7 0.13 1.9 2.1 2.1 2.1 0.13 2.1 2.1 2.1 2.1 2.1 2.1 2.1 2.1 2.1 2.1	 2.3		0.38	39.58	1	1	1	1			0.5
2.1 0.19 2.1 0.13 2.1 0.13 2.2 0.15 2.4 0.13 19.5 0.13 2.4 0.13 2.4 0.13 2.4 0.13 2.4 0.13 3.4 0.24	 2.3		0.34	40.25	1						-
2.1 0.15 2.1 0.13 2.1 0.19 2.7 0.15 2.4 0.13 1.9 0.14 1.9 0.14 1.9.5 3.4 2.1 0.24	 . !		0.19	38.27	1						
2.1 0.13 2.1 0.19 2.7 0.15 2.4 0.13 1.9 0.14 19.5 3.4 2.1 0.12	 2.1		0.15	40.19	1	1		1 1 1 1			1
2.7 0.19 2.7 0.18 2.4 0.13 1.9 0.14 19.5 3.4 3.3 0.24	 2.1		0.13	36.60							1.5
2.7 0.19 2.4 0.13 1.9 0.14 19.5 3.4 2.1 0.12	 1.9		0.17	15.02	1						1.5
2.7 0.15 2.4 0.13 1.9 0.14 19.5 3.4 2.1 0.12	 2.1	1	0.19	53.33	1					1	1.5
19.5 0.13 19.5 3.4 2.1 0.12 3.3 0.24	 2.7		0.15	45.86	!	!		1			2
19.5 2.1 3.3 0.24	 2.4		0.13	41.27			-	1			2
2.1 3.3 0.24	 1.9		0.14	43.78	1		1				3.5
3.3 0.24	 19.5		3.4	66.80				1			4.5
3.3 0.24	 2.1		0.12	52.45	1 1 1 1 1 1						3.5
	 3.3		0.24	62.21							3.5

DATE		TURBIC	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES. Al/Fe (mg/l	RES. (mg/L)	Hd	TEMP.
חאונ	Raw	Set.	Filter	Treat.	J/bw	mg/L	1/6m	Raw	Treat.	Raw Treat	-
_	144.80	6.6		0.34	72.44						2.5
2	126.50	6.8		0.37	67.67	1 - 1					2.5
3	73.30	5.3		0.28	62.84		1				5.0
4	50.60	3.0	1	0.20	57.05	i ! !			1		4.0
- 2	62.50	4.2		0.19	56.04	1		1			5.0
9	24.80	2.4		0.30	48.92	1 1 1 1					2.5
7	11.30	1.7	1	0.18	48.71	1	1				5.0
8	9.90	2.1		0.10	39.85		1	- <del>-  </del>			4.0
6	5.40	1.6	1	0.11	28.34			·			2.0
91	3.90	1.6	1	0.10	27.34	1 1 1 1 1 1					2.0
=	4.16	1.9		0.10	22.50	 			1		2.5
12	9.21	2.5		0.11	35.72	1					3.0
13	25.90	1.5		0.09	40.32		1	· – <del>'</del>		· — -	3.5
14	25.00	1.9		0.09	46.28					· <del>-  </del>	4.5
15	13.50	1.9	1	0.11	34.15						0.5
_											

TEMP.   (oC)	≃	5.0	5.0	5.5	6.5	6.5	6.9	6.5	7.0	8.5	8.5	8.0	8.0	8.0	7.5	6.5	
Fd	Raw   Treat						· :				1		· <u>-                                   </u>				
METAL RES.	Raw   Treat.																
	Raw																
FILTER	1/6m																-
COAG.	1/5w																-
COAGULANT	mg/L	35.65	45.67	31.53	39.11	34.04	31.97	41.25	40.80	28.13	28.16	27.53	20.90	27.95	22.72	21.52	1
	Treat.	0.09	0.09	0.10	0.09	0.10	0.10	0.11	0.17	0.11	0.10	0.10	0.10	0.13	0.19	0.13	
TURBIDITY (FTU)	Filter																1
TURBI	Set.	1.4	1.6	1.6	1.9	1.9	1.7	1.2	1.2	1.5	1.3	1				<u>:</u>	-
	Raw	12.66	18.50	16.60	19.50	12.70	10.05	6.20	4.40	4.10	5.40	4.20	3.70	2.60	2.30	2.10	-
DATE	DA I	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

		TURBII	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	Al/Fe (mg/	RES.		Hd	TEMP.
DAIL	Raw	Set.	Filter	Treat.	1/5m	mg/L	1/6w	Raw	Raw Treat.	Raw	Treat.	Raw
-	3.60	1.4		0.12	32.63	1				1		-7:0
2	2.40	1.2	1	0.11	18.16				. !	-	1	7.5
3	2.10	1.1		0.14	20.52					1		7.0
4	2.20	1.1		0.10	22.74	1						7.0
5	2.10	1.0		0.11	25.36			1				7.0
9	2.40	1.2		0.11	22.92							7.0
7	2.40	1.3		0.12	21.31			1	1			8.0
	2.70	1.2		0.12	32.25				1		1	8.5
6	1.82	1.1		0.11	17.87				1			7.0
10	1.98	1.3		0.14	20.14				1		1	8.0
===	1.87	1.3		0.12	17.18				3	1	1	8.5
12	2.12	1.2	1	0.14	16.99						1	8.0
13	2.35	1.4		0.17	17.88						1	8.5
14	2.30	1.2		0.14	19.02			1				9.0
15	3.05	1.2	1	0.14	17.65							0.6

UMBIDITY (FTU)   ALIM   ALIB	L		10000	1000		COAGULANT	COAG.	FILTER	METAL RES	RES.	1		TEND.
Set.         Filter         Treat.         mg/l         mg/l           1.5         0.11         24.01         1.1         1.2         1.1         1.1         1.2         1.1         1.2         <	_		I OKB I	)   (+ 10)	_	ALUM	AID	AID	Al/Fe (mg/L	(1/Eu)		- I	(00)
1.5 0.11 1.6 0.12 1.1 0.12 1.1 0.14 1.2 0.12 1.1 0.14 1.1 0.13 1.1 0.13 1.1 0.13 1.1 0.13 1.1 0.13 1.1 0.13		WE	Set.	Filter	reat.	J/6w	mg/L	1/Ew	Raw	Treat.	Raw	Treat.	Kaw
2.60     1.5     0.11       3.00     1.6     0.12       3.00     1.5     0.12       2.40     1.3     0.15       1.70     0.9     0.12       1.60     1.2     0.14       1.70     1.2     0.14       1.80     1.0     0.13       1.80     1.1     0.13       2.50     1.1     0.13       2.30     1.1     0.13       1.80     1.2     0.14       2.30     1.1     0.13       1.80     1.2     0.10       1.70     1.2     0.10		92	1.5		0.11	24.01							9.5
3.00         1.6         0.12           3.00         1.5         0.12           2.40         1.3         0.15           1.80         1.1         0.14           1.70         0.9         0.12           1.70         1.2         0.14           1.70         1.1         0.12           1.80         1.1         0.13           2.50         1.1         0.13           2.50         1.1         0.13           2.50         1.1         0.13           2.50         1.1         0.10           1.80         1.2         0.10		09	1.5		0.11	20.14							9.5
3.00   1.5   0.12     2.40   1.3   0.15     1.80   1.1   0.14     1.70   1.2   0.12     1.70   1.1   0.13     1.80   1.1   0.13     2.50   1.1   0.14     2.10   1.2   0.14     2.10   1.1   0.15     2.10   1.1   0.15     3.00   1.2   0.16     4.10   0.15     5.10   1.1   0.15     5.10   1.1   0.15     5.10   1.2   0.15     5.10   1.1   0.15     5.10   1.2   0.15     5.10	<u></u>	8	1.6	1	0.12	22.72	_						10.0
2.40     1.3     0.15       1.80     1.1     0.14       1.70     0.9     0.12       1.70     1.2     0.14       1.70     1.1     0.13       1.80     1.0     0.13       2.50     1.1     0.13       2.30     1.1     0.14       1.80     1.2     0.10       1.30     1.2     0.10	<u>-</u> -	8	1.5		0.12	25.56							10.0
1.80   1.1   0.14   1.70   1.2   0.13   1.80   1.1   0.13   1.80   1.1   0.13   1.80   1.1   0.13   1.80   1.1   0.13   1.80   1.1   0.13   1.80   1.1   0.13   1.80   1.1   0.14   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15   1.80   1.2   0.15	.2	40	1.3		0.15	19.28	1						10.0
1.70         0.9         0.12           1.60         1.2         0.14           1.70         1.2         0.13           1.80         1.0         0.13           1.80         1.1         0.13           2.50         1.1         0.13           2.90         1.1         0.14           1.80         1.2         0.10		.80	1.1		0.14	22.70	1						10.5
1.60         1.2         0.14           1.70         1.1         0.13           1.80         1.0         0.13           2.50         1.1         0.13           2.30         1.1         0.14           2.30         1.1         0.12           1.80         1.2         0.10		07.	6.0		0.12	21.14				         			9.5
1.70     1.2     0.12       1.80     1.0     0.13       1.80     1.0     0.14       2.50     1.1     0.14       2.30     1.1     0.12       1.80     1.2     0.10       1.70     1.2     0.15		09:	1.2		0.14	17.75				1			10.5
1.70         1.1         0.13           1.80         1.0         0.14           1.80         1.1         0.13           2.50         1.1         0.12           1.80         1.2         0.10           1.70         1.2         0.16		. 70	1.2		0.12	17.50							11.0
1.80     1.0     0.14       1.80     1.1     0.13       2.50     1.1     0.14       2.30     1.1     0.12       1.80     1.2     0.10       1.70     1.2     0.15		2	1.1		0.13	18.75	1						11.0
2.50 1.1 0.13 0.14 0.18 0.10 0.10 0.10 0.10 0.15		8	1.0		0.14	17.13				1		-	9.0
1.1 0.14			1.1		0.13	16.33							9.0
1.1 0.12	- 5	-20	1.1		0.14	18.76	1						11.0
1.2 0.10	2	8	1.1		0.12	17.14				1			11.0
1.2 0.15		98	1.2		0.10	15.74	1						12.0
7:1		1.70	1.2		0.15	22.52							12.0

### PROFILE JUNE 1985 ... MOE WPOS PROTOCOL

1		TURBIC	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	Al/Fe (mg/	RES.		핊	TEMP.
T N	Raw	Set.	Filter	Treat.	mg/L	1/6w	1/bw	Raw	Treat.	Raw	Treat.	Raw
	2.20	1.0		0.11	24.61	1 1 1 1 1 1			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1	
2	1.80	1.1		0.11	18.04	1						
9	1.70	1.1		0.11	21.19			1 1 1	1			
4	1.90	1.2		0.10	19.48						1	
2	1.70	1.0		0.11	16.60							
9	1.30	1.1		0.13	16.87	1			1	-		
7	1.40	1.2		0.15	24.53	1 1 1 1 1			1	-		
8	1.60	1.2		0.14	11.22				1			
6	1.80	1.3		0.15	15.21	 				-		
10	1.60	1.5		0.15	21.08	 			1	-	1	
=	1.50	1.1		0.13	19.28		!			-		1
12	1.90	1.2		0.14	19.00		1		1	-		
13	2.50	1.3		0.14	20.33		1					
14	1.80	1.2		0.13	17.83				1 1 1 1 1			
15	1.30	1.3		0.13	18.39							

(oc)	Raw																
pH	Treat.	1			-		-										
	Raw		1			1											
METAL RES. Al/Fe (mg/L)	Treat.		1			1		1	1			1		1	1	1	
METAL RES. Al/Fe (mg/l	Raw			-													
FILTER A	mg/L				1 1 1 1 1 1		1		-				-			-	
COAG.	mg/L		. !									1 1 1 1	1	1	1	1	
COAGULANT	mg/L	17.41	14.87	20.68	18.10	20.15	15.57	16.02	16.32	17.49	17.33	18.98	19.33	22.43	21.15	19.85	
	Treat.	0.12	0.13	0.14	0.12	0.12	0.09	0.10	0.10	0.17	0.13	0.12	0.11	0.15	0.14	0.14	
TURBIDITY (FTU)	Filter		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						1				-	1			
TURBID	Set.	6.0	1.0	1.1	6.0	1.0	0.7	6.0	1.1	1.2	1:1	1.0	1.2	1.2	1.1	1.3	
	Raw	1.20	1.20	1.60	1.50	1.50	1.30	1.40	2.40	1.70	1.40	1.50	1.70	2.30	1.90	2.30	
DATE	1	16	17	18	19	20	21	22	23	24	25	26	-21	28	29	30	33

					COAGULANT	COAG.	FILTER	METAL	RES.	7	TEMP
DATE		TURBI	TURBIDITY (FTU)	_	ALUM	AID	AIO	A1/Fe	Al/Fe (mg/L)	ᆲ	
	Raw	Set.	Filter	Treat.	mg/L	1/6w	mg/L	Raw	Treat.	Raw Treat	at. Raw
	2.10	1.4		0.15	17.19						15.0
2	1.60	1.2		0.15	15.36				- 1		15.5
	2.00	1.3		0.15	17.07						16.5
4	1.53	1.2		0.17	15.59	1					17.0
	1.82	1.4		0.19	19.33	1					8.0
9	1.78	1.3		0.19	11.95						10.0
7	1.45	6.0		0.14	16.80				1		14.5
8	1.30	1.1	1	0.12	11.80				1		14.5
6	1.23	0.7	1	0.13	19.00				1		14.5
91	1.05	8.0	1	0.13	18.33						18.0
=	1.10	6.0	1	0.11	16.90				1		18.0
12	1.40	1.3	1	0.14	19.57						16.0
13	1.50	1.2		0.14	19.33						10.0
14	1.90	1.3		0.17	21.35						8.5
15	2.00	1.3		0.14	19.92	1					8.5

		24.40 17.52 21.02 18.72 18.47 16.55
		17.52 21.02 18.72 16.55 16.47 16.90
		21.02 18.72 18.47 16.55 16.47
		18.72 18.47 16.55 16.47
		16.55
		16.55 16.47 16.90
		16.90
	_	16.90
-	į	
-		20.89
		17.83
		17.12
-		16.68
-		20.31
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	!	16.50
		21.07
		20.14

		THRBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL A1/Fe	RES.	ā	Ħ	TEMP.
DAIL	Raw	Set.	Filter	Treat.	mg/L	J/Bm	1/6w	Raw	Raw Treat.	Raw	Treat.	Raw
	3.50	1.5		0.13	20.83							12.0
2	3.90	1.9	1	0.14	29.35	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				1		14.5
m	1.10	1.3		0.15	19.05					1	1	17.0
4	1.30	1.3	1	0.15	12.37				1			18.0
	1.40	1.1		0.15	21.48			1	1			16.0
9	1.40	1.3		0.15	15.05							16.5
	1.60	1.3		0.16	15.35						!	16.0
8	2.10	1.4		0.17	17.41	1 1 1 1 1 1						18.0
6	2.20	1.6	1	0.19	16.37				1			17.5
10	1.80	1.5	1	0.18	18.73			-	1			17.5
=	3.50	2.0	1	0.20	24.56			1	1			17.5
112	12.00	1.9		0.20	26.49			1				18.5
13	5.30	2.1	1	0.24	30.33					1		17.5
14	3.80	1.9	1	0.27	26.95						1	19.5
15	3.70	1.4		0.28	25.39							20.0

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		THREE	THRBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES	RES.	苖		TEMP.
DAIL	Raw	Set.	Filter	Treat.	MJ/Em	1/6m	1/bw	Raw Trea	Treat.	Raw	Treat.	Raw
91	4.80	1.9		0.20	25.15							20.0
17	3.90	1.7		0.19	33.44							20.0
18	2.90	6.0		0.17	21.82	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						19.0
61	2.70	1.3		0.15	18.21			-	1			18.0
20	2.80	1.5		0.15	15.85				-			18.5
21	2.90	1.3		0.15	19.36	1						18.0
22	2.60	1.5	1	0.17	15.82							18.0
23	2.30	1.5		0.18	17.44	1						18.0
24	8.40	1:1		0.15	25.25							18.0
25	33.50	6.0		0.13	45.53							16.0
26	16.30	0.7		0.14	37.79	1						18.0
27	7.30	0.8		0.11	37.14							19.0
28	3.60	1.0		0.12	22.75							19.0
29	8.76	1.1		0.15	24.03			-				18.5
30	16.80	1.4		0.14	33.79	# # # 1 1 1 1 1						18.5
31	24.17	1.3		0.16	34.65							18.0

## SEPTIMBER 1985

J. V.		TURBIL	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	Al/Fe (mg/l	RES.	d	Hd	TEMP.
4	Raw	Set.	Filter	Treat.	mg/L	mg/L	1/5w	Raw	Raw Treat.	Raw	Treat.	Кам
	8.53	1.0		0.12	19.56	1 1 1 1 1 1 1			1		1	17.5
	4.30	1.1		0.12	25.47	1					1	18.0
3	3.18	6.0		0.12	21.80							18.0
4	3.10	1.2	1	0.13	14.83							18.0
	2.60	1.3	1	0.13	18.79							19.0
9	2.60	1.2	1	0.13	19.01							19.0
	2.30	1.2		0.15	16.48	1 1 1 1 1 1 1 1 1						20.0
8	2.30	1.1		0.17	19.32	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					1	20.5
6	11.50	1.0		0.16	32.09	) 						19.0
10	9.50	1.1		0.12	31.43				1			18.5
==	17.80	0.8	1	0.10	30.84			1				19.0
12	12.30	1.9	1	0.21	27.72					1		18.0
13	13.30	0.7	1	0.10	40.39							17.0
14	2.70	1.2	1	0.10	18.39					-		17.0
15	1.60	1.4		0.14	20.40	#	:					17.0

		1	10000		COAGULANT	COAG.	FILTER	METAL	METAL RES.	H	_	LENP.
DATE		IOKBI	IUKBIDITY (FIU)	_	ALUM	AID	AID	A1/Fe	(mg/L)	- 1		(70)
_	Raw	Set.	Filter	Treat.	7/Ew	mg/L	1/6w	Raw	Treat.	Raw	reat.	Kaw
16	2.20	0.8		0.11	23.62							16.5
17	2.20	1.3		0.13	11.87							17.0
18	1.90	0.7		0.12	19.59	1	1					17.0
19	2.50	1.0		0.11	21.84	1		1	1			17.0
50	2.60	1.0		0.11	19.98	.			1			17.0
21	3.50	1.0	, ,	0.12	20.99		1	1				17.0
22	5.00	6.0		0.13	28.52			-				16.0
23	3.00	1.0		0.12	22.20	1				1		17.0
24	2.80	6.0		0.12	27.20			1	•			17.5
25	2.70	1.1		0.11	20.11			1	1			17.0
26	7.55	1.0	1	0.13	27.93		-	1				17.0
27	16.85	1.2		0.13	32.33							16.5
28		1.1	1	0.08	29.53			1				15.0
29	5.30	1.2	1	0.11	22.19			1				15.5
30	3.25	6.0	1	0.0	22.81			1 1 2 3	1			15.5
31												

					COAGULANT	COAG.	FILTER	METAL RES	RES.		100	TEMP.
DATE		TURBI	TURBIDITY (FTU)	_	ALUM	AID	AIG	A1/Fe	(1/6m)	- 1		()
	Raw	Set.	Filter	Treat.	mg/L	T/6m	1/6w	Raw	Treat.	Kaw	lreat.	Kaw
	2.68	6.0		0.10	21.86	1			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1	1	14.5
- 5	3.01	6.0		0.11	21.76	)             			. 1	-	-	15.0
3	4.90	1.0		0.10	19.71	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			1	1	1	16.0
4	4.40	0.8		60.0	25.96			. — -	1			15.0
5	3.80	1.1		0.15	24.72			1 1 1 1 1	1			12.5
9	2.90	6.0		0.13	18.71	1					)   	12.0
7	2.70	6.0		0.11	21.50	1				)         		11.0
8	2.10	1.3		0.13	16.88				1			10.0
6	1.90	1.1	1	0.14	16.83						. !	8.5
01	2.20	1.1		0.10	24.92						1	9.6
=	1.90	6.0		0.11	18.93				1		1	9.0
12	3.70	6.0	 	0.12	17.86				1			7.5
13	8.90	1.2	1	0.10	27.95				1			0.6
14	5.30	1.1	1	60.0	23.88					1	1	8.5
15	4.40	1.3	<u> </u>	0.10	27.41	1						8.5
_												

ridiodist	ri di dani	3	11.27		COAGULANT	COAG.	FILTER	METAL	METAL RES.	2	TEMP.
IUKBIDIIY (FIU)	IUKBIDIIY (FIU)	DIIY (FIU)	_	_	ALUM	AID	AID	A1/Fe	(1/6m)	-	(00)
Raw   Set.   Filter   Treat.	Filter		Treat.		1/6m	mg/L	mg/L	Raw	Treat.	Raw Treat	Raw
2.80 1.2 0.10		0.10	0.10		25.85				1		8.0
2.40 1.3 0.10		0.10	0.10		20.88						7.5
2.00 1.1 0.11		0.11	0.11		14.91	1		:	1		8.0
2.20 1.3 0.12		0.12	0.12		14.34			1			0.6
18.70 1.1 0.11		0.11	0.11		27.38	1		-			9.0-
12.70 1.2 0.09		0.09	0.09		40.52	1					8.0
15.50 1.2 0.10		0.10	0.10		44.16	1			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		8.5
4.40 1.1 0.10		0.10	0.10		26.02	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					9.5
2.01 1.1 0.11		0.11	0.11		16.64	1					9.5
1.90 1.1 0.09		0.00	0.09		19.00		1				- 10.0
1.81 0.9 0.07		0.07	0.07		20.74						10.0
2.36 1.1 0.08		0.08	0.08		15.77	1					10.0
4.41 1.0 0.09		0.00	0.0		20.65	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					10.0
3.56 0.8 0.09		0.09	0.00		24.68						
10.03 1.0 0.08		0.08	0.08		26.57	 			1		8.5
22.60 0.7 0.08		0.08	0.08		34.87						0.6
				-1							

# TABLE 2.1: PARTICULATE REMOVAL PROFILE NOVEMBER 1985.

					ACAR III ANT	0400	CTITED	META! DEC			TUMO
DATE		TURBIL	TURBIDITY (FTU)		COAGULANI	CDAG.	AlD	Al/Fe (mg/L)		рН	(OC)
	Raw	Set.	Filter	Treat.	1/6w	mg/L	1/6m	Raw Trea	t. Raw	Treat.	Raw
-	47.80	1.6		0.08	44.53						8.5
2	25.80	1.6	!	60.0	39.53			1			8.5
3	31.80	1.6		0.07	42.79					.	8.0
4	56.50	1.3	1	0.10	48.19						8.0
5	82.30	1.2		0.14	59.37					1	8.0
9	46.50	1.5	1	1.82	96.09						7.5
7	46.30	1.9	1	0.17	85.32						3.0
	23.20	1.9		0.08	49.03						7.5
6	33.30	1.7		0.10	63.29			1			7.0
10	31.20	1.6		0.10	50.44						7.5
11	51.60	2.9		0.14	68.77						0.9
12	33.00	2.8		60.0	55.40						0.9
13	09.9	4.8		0.13	28.07			-			6.0
14	28.20	2.2		0.46	47.55						0.9
15	22.90	1.7		0.0	54.24	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			<u>-</u> -		0.9
									-		

Mg/L Kaw Ireat. Raw Ir	COAGULANT COAG.
5.0 5.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7	/bw
5.0 6.5 7.5 7.6 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6	
5.0 7.5 7.6 6.0 6.0 6.0 6.0 6.0 6.0 6.0 6	
7.5. 7.0 7.0 7.0 5.5 5.5 5.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7	
7.5 7.0 7.0 6.0 6.0 5.5 5.5 5.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7	
5.5	
5.5	
5.5	
5.5	
5.0	
5.0.	
5.9.	
5,0	
5.9.	
5.0	

Raw         Set.         Filter         Treat.         mg/L         mg/L         Ray         Treat.         Ray         Treat.           24.20         2.4         0.12         40.86         86.67	DATE		TURBIG	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	Al/Fe (mg/l	RES. (mg/L)	Hd		TEMP.
24.20         2.4         0.12         40.86           26.20         2.4         0.13         54.67           25.60         4.3         0.11         46.74           25.60         4.3         0.21         40.87           25.16         4.7         0.18         61.67           17.83         2.4         0.19         41.34           15.16         1.8         0.13         34.81           15.16         1.8         0.12         26.43           6.05         2.0         0.11         26.36           6.05         2.0         0.11         26.36           8.18         2.1         0.09         29.29           10.00         1.3         0.09         29.29           10.00         25.85         0.15         25.85           10.00         2.5         0.15         19.52	=	Raw	Set.	Filter		1/5w	1/bw	1/6w	Raw	Treat.		eat. Raw	3
26.20         2.4         0.13         54.67           15.50         1.5         0.11         46.74           26.60         4.3         0.21         40.87           25.16         4.7         0.18         61.67           17.83         2.4         0.19         41.34           15.16         1.8         0.13         34.81           15.16         1.8         0.13         34.81           6.05         2.0         0.12         26.43           6.05         2.0         0.11         26.36           6.36         2.0         0.11         26.36           8.18         2.1         0.09         29.29           10.70         0.15         25.85           7.70         1.8         0.15         19.52		24.20	2.4		0.12	40.86	1 1 1 1 1 1	1				5.0	
15.50         1.5         0.11         46.74         46.74           26.60         4.3         0.21         40.87         61.67           17.83         2.4         0.18         61.67         61.67           17.83         2.4         0.13         34.81         61.67           15.16         1.8         0.12         26.43         66.03           6.05         2.0         0.12         26.43         66.05           6.05         2.0         0.11         26.36         67.36           8.18         2.1         0.10         26.36         67.36           13.90         1.7         0.08         32.75         67.86           10.70         1.3         0.09         29.29         67.86           10.70         1.8         0.15         25.85         67.86	7 7	26.20	2.4	1	0.13	54.67	   1   1   1   1			1		4.0	
26.60         4.3         0.21         40.87           25.16         4.7         0.18         61.67           17.83         2.4         0.19         41.34           15.16         1.8         0.13         34.81           6.05         2.0         0.12         26.43           6.05         2.0         0.11         26.36           6.16         0.10         26.52           8.18         2.1         0.09         29.29           10.70         1.3         0.05         29.29           7.70         1.8         0.15         19.52	] m	15.50	1.5	1	0.11	46.74	1 1 1 1 1					3.5	
25.16         4.7         0.18         61.67           17.83         2.4         0.19         41.34           15.16         1.8         0.12         26.43           6.05         2.0         0.12         24.56           6.05         2.0         0.11         26.36           8.18         2.1         0.00         26.52           10.70         1.3         0.09         29.29           10.70         0.15         25.85           9.10         2.6         0.15         19.52	4	26.60	4.3	1	0.21	40.87	1 1 1 1 1 1	1		-		1.0	
17.83         2.4         0.19         41.34         6.13           15.16         1.8         0.12         26.43         6.05         6.05         2.0         0.12         26.43         6.05	2	25.16	4.7		0.18	61.67						2.5	
15.16         1.8         0.13         34.81         6.05         2.0         0.12         26.43         6.05         2.0         0.12         24.56         6.05         2.0         0.11         26.36         6.05         2.0         0.11         26.52         6.05         2.0         0.00         29.29         7.70         1.3         0.09         29.29         7.70         1.8         0.15         25.85         9.10         25.85         8.18         1.52         19.52	9	17.83	2.4		0.19	41.34			1	1		3.0	
5.53         1.3         0.12         26.43         6.06         2.0         0.12         24.56         6.36 <td< th=""><th>7</th><th>15.16</th><th>1.8</th><th></th><th>0.13</th><th>34.81</th><th>1 1 1</th><th></th><th></th><th></th><th></th><th>2.5</th><th></th></td<>	7	15.16	1.8		0.13	34.81	1 1 1					2.5	
6.05         2.0         0.12         24.56         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.36         6.37         6.37         6.37         6.37         6.37         6.37         6.37         6.37         7.70         7.30 <td< th=""><th>8</th><th>5.53</th><th>1.3</th><th></th><th>0.12</th><th>26.43</th><th>1 5 3 5 1 1</th><th></th><th></th><th>1</th><th></th><th>3.0</th><th></th></td<>	8	5.53	1.3		0.12	26.43	1 5 3 5 1 1			1		3.0	
6.36         2.0         0.11         26.36           8.18         2.1         0.10         26.52           13.90         1.7         0.08         32.75           10.70         1.3         0.09         29.29           7.70         1.8         0.15         25.85           9.10         2.6         0.15         19.52	6	6.05	2.0		0.12	24.56	1			1		3.0	
8.18         2.1         0.10         26.52           13.90         1.7         0.08         32.75           10.70         1.3         0.09         29.29           7.70         1.8         0.15         25.85           9.10         2.6         0.15         19.52	0	6.36	2.0		0.11	26.36	1			1		3.0	
13.90         1.7         0.08         32.75           10.70         1.3         0.09         29.29           7.70         1.8         0.15         25.85           9.10         2.6         0.15         19.52	=	8.18	2.1		0.10	26.52	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					4.0	
10.70     1.3     0.09     29.29       7.70     1.8     0.15     25.85       9.10     2.6     0.15     19.52	- 21	13.90	1.7		0.08	32.75	1					3.0	
7.70         1.8         0.15         25.85           9.10         2.6         0.15         19.52	13	10.70	1.3		60.0	29.29				1		0	
9.10 2.6 0.15 19.52	4	7.70	1.8		0.15	25.85				1		2.0	
	2	9.10	2.6		0.15	19.52						1 2.0	

Page 2 of 2

0.10 21.60 0.12 29.51 0.09 11.41 0.09 11.64 0.00 0.10 12.36 0.10 0.10 12.37 0.10 0.10 15.78 0.10 15.78 0.10 15.78 0.10 15.78 0.10 15.78 0.10 15.78 0.10 15.78 0.10 15.78 0.10 15.78 0.10 0.10 15.78 0.10 0.10 15.78 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.1	THREE	THERIOTTY (FTII)		COAGULANT	COAG.	FILTER	METAL RES	RES.		Ha	TEMP.
0.10 21.60 0.12 29.51 0.16 26.33 0.23 24.29 0.14 23.00 0.11 17.78 0.10 18.62 0.09 11.41 0.10 18.62 0.09 17.60 0.10 18.62 0.10 18.62 0.10 18.62 0.10 12.37 0.11 12.85 0.09 42.58	Set.	Filter	Treat.	Md/L	A10 mq/L	AID mg/L	Raw Raw	(mg/L) Treat.	- 1	Treat.	Raw
1.3 1.3 1.9 1.9 1.13 1.13 1.13 1.13 1.14 1.15 1.10 1.10 1.10 1.10 1.11	 ĺ		,	3							-
1.3 1.9 1.9 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3	 2.1		0.10	21.60				1	1 1 1		1.0
1.9 0.16 1.3 0.11 1.3 0.09 1.3 0.09 1.3 0.09 1.1 0.11 1.1 0.11 1.1 0.11 1.1 0.11	 1.3		0.12	29.51				1	1	1	0.5
1.3 1.3 1.5 1.3 1.3 1.3 1.3 1.3 1.3 1.3 1.3	 1.9		0.16	26.33	1 1 1 1 1 1				1		0.5
1.3 0.14 1.5 0.11 1.3 0.09 1.3 0.09 1.3 0.08 1.1 0.10 1.1 0.10 1.1 0.11 0.09	 1.9		0.23	24.29	1 1 3 1 1 1 1						0
1.3 0.11 1.3 0.09 1.3 0.08 1.3 0.08 1.1 0.11 1.1 0.11 1.1 0.11 0.9	 3.1		0.14	23.00				1	1		0
1.5 0.11 1.3 0.09 1.3 0.08 1.1 0.10 1.1 0.11 1.1 0.11 0.09	 1.3		0.11	17.78				1			0
1.3 0.09 1.3 0.08 1.1 0.08 1.1 0.10 1.2 0.10 1.1 0.11 0.9 0.09	 1.5		0.11	17.49	1				1	-	0
1.5 1.2 1.1 1.1 1.1 1.1 1.1 0.10 0.10 0.11 0.11 0.11	 1.3		60.0	11.41				1	1	1	0.5
1.3 0.08 1.1 0.10 1.1 0.10 1.1 0.11 0.9 0.09	 1.5		0.10	18.62	1				1		0.5
1.1 1.2 1.1 1.1 1.1 0.0 0.0 0.0	 1.3		0.08	17.60	) ) ) ) )				1		0
1.1 0.10 1.1 0.11 0.9 0.09	 1.2		0.11	11.64		1		-			0
1.2 0.10 1.1 0.11 0.9 0.09	 1.1		0.10	12.37	1			1			0
1.1 0.11 0.11 0.09	 1.2		0.10	15.78					1 1 1	-	0
0.9	 1.1		0.11	12.85	1			1			0
6.0	 1.1		0.11	9.20							0
	 6.0		60.0	42.58							0

# TABLE 2.1: PARTICULATE REMOVAL PROFILE JANUARY 1984.

- ;		1000	IUKBIDITY (FIU)	_	ALUM	AID	AID	A1/Fe (mg/L)	(T/Em)	直	(oc)
	Raw	Set.	Filter	Treat.	mg/t	mg/L	1/6m	Raw	Treat.	Raw Treat.	Raw
!	2.18	4.3		0.22	27.74	1					0
	2.05	2.6		0.22	30.10	1				-	0
<del>!</del>	1.85	2.1		0.19	21.71	1					0
<del>-</del> – -	1.82	2.1		0.14	20.27	 					0
<del>:</del>	1.60	2.8		0.23	21.16		1	· — <del> </del>			0
<del> </del>	2.80	1.9	1	0.18	22.06						0
<del>-</del>	00.6	1.8		0.15	35.02	1					0
:	3.70	2.3		0.12	28.83						
	3.00	1.9		0.14	26.91						0
¦	11.88	2.4		0.17	37.70						0
	15.00	2.3		0.45	50.22	1					10
	12.00	2.6	1	0.33	34.55						
	12.50	2.2		0.17	38,33	1			-		0
	14.90	2.1		0.25	53.18					-	0
	9.80	2.1		0.19	33.71						0

DATE		TURBIL	TURBIDITY (FTU)		COAGULANT	COAG. AID	FILTER	META! A1/Fe	METAL RES. Al/Fe (mg/L)		표	(0C)
:	Raw	Set.	Filter	Treat.	1/6w	mg/L	1/6w	Raw	Treat.	Raw	Treat.	Raw
16	7.20	2.3		0.31	39.54		1	1	) 	! !		0
17	5.00	2.0		0.29	31.52	1	) + 1 1 1	-	1		-	0
18	3.20	2.4	1	0.17	25.51				1	1 1	-	0
19	4.20	1.9	1	0.22	24.34				1	-		0
20	4.08	2.1		0.35	31.82							0
21	3.92	1.9		0.36	27.83	1	1					10
22	3.50	1.8		0.38	27.20							
23	2.62	1.6		0.30	21.32	1				-		10
24	2.28	1.6		0.19	20.73				1	-		10
25	2.70	1.6		0.15	22.16							0
26	2.00	1.6		0.14	17.47				1		-	0
-12	3.92	1.5		0.13	21.66						-	0
28	3.00	1.7		0.21	26.38	1	+ 1			-		0
29	3.83	1:7		0.16	26.50				1	-		10
30	4.28	1.4		0.18	24.41				1			0
31	11.17	1.7		0.24	25.97							0
					•		•					

DATE		TURBII	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES. Al/Fe (mq/l	RES. (mq/L)		五	1EMP.
5	Raw	Set.	Filter	Treat.	mg/L	mg/t	1/5w	Raw	Treat.	Raw	Treat.	Raw
	6.20	3.3		0.18	37.21	1	 				1	0
- 5	6.40	2.5		0.22	35.78		1		.			0
3	3.30	1.9		0.26	28.61					1	1	0
4	4.20	2.4		0.51	28.68			1				0
	3.50	2.3		0.26	31.47	1		-	-		1	0
9	3.30	2.2		0.19	25.02	1 1 2 1 1 1	1			1	1	0
	3.70	2.4		0.24	26.50	1 1 1 1 1 1 1						0
8	1.98	1.9		0.21	21.38		1					0
6	2.75	1.9		0.16	15.79		1				1	0
01	5.20	2.3		0.15	24.46	1 1 1 1 1 1				1	-	0
=	3.90	2.0		0.15	31.11	1					1	0.5
12	8.80	3.0		0.18	34.77						1	0.5
13	13.30	2.8		0.41	49.82		1		1			0.5
14	82.50	5.4		0.23	66.28							1.0
15	37.60	5.0		0.29	68.61							1.0
_	_											

DATE         Raw         Set.         FURBILITY (FUU)         ALIAM         ALIAM						COAGULANT	COAG.	FILTER	METAL	RES.	_		TEND.
Raw         Set.         Filter         Treat.         Raw	DATE		TURBI	מוזא (דוט	_	ALAM	AID	l AID	A1/Fe	(mg/L)	- 1		() ()
36.17     4.6     0.69     91.60       36.17     4.2     0.65     77.88       31.50     5.1     0.33     70.87       12.50     3.4     0.27     70.04       11.95     2.7     0.34     39.38       11.95     2.7     0.24     37.46       4.67     1.9     0.24     37.46       12.90     1.9     0.28     50.66       8.07     1.5     0.21     41.66       8.07     1.5     0.27     74.97		Raw	Set.	Filter	Treat.	J/6w	mg/L	1/6 <b>w</b>	Raw	Treat.	Raw	Treat.	Кам
36.17     4.2     0.655     77.88       31.50     5.1     0.33     70.87       12.07     2.3     0.27     70.04       11.95     2.7     0.34     39.38       11.95     2.7     0.24     37.46       4.67     1.9     0.24     37.46       12.90     1.9     0.28     50.66       12.90     1.5     0.21     40.85       139.30     4.2     74.97	16	36.17	4.6		69.0	91.60			1	1		1	1.0
31.50     5.1     0.33     70.87       24.50     3.4     0.27     70.04       12.07     2.3     0.32     40.78       11.95     2.7     0.34     39.38       4.67     1.9     0.21     34.77       4.67     1.9     0.24     37.87       12.90     1.9     0.28     50.66       3.53     1.6     0.25     40.85       8.07     1.5     0.27     75.86       139.30     4.2     0.15     74.97	17	36.17	4.2	1	0.65	77.88				1			1.5
13.450       3.4       0.277       70.04         11.207       2.3       40.78         11.95       2.7       0.34       39.38         8.90       2.5       0.21       34.77         4.67       1.9       0.24       37.46         12.90       1.9       0.28       50.66         12.90       1.5       0.21       41.66         139.30       4.2       0.27       75.86	18	31.50	5.1		0.33	70.87	1	1					1.5
11.07     2.3     0.32     40.78       11.195     2.7     0.34     39.38       8.90     2.5     0.21     34.77       4.67     1.9     0.24     37.46       12.50     1.9     0.28     50.66       3.53     1.6     0.25     40.85       8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	19	24.50	3.4		0.27	70.04				1	1	1	2.0
11.95     2.7     0.34     39.38       8.90     2.5     0.21     34.77       4.67     1.9     0.24     37.46       12.90     1.9     0.28     50.66       3.53     1.6     0.25     40.85       8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	20	12.07	2.3		0.32	40.78	1				-	1	2.5
8.90     2.5     0.21     34.77       3.68     1.6     0.18     37.46       12.90     1.9     0.28     50.66       3.53     1.6     0.25     40.85       139.30     4.2     0.27     75.86	21	11.95	2.7		0.34	39.38	]   	1		1	1		2.0
3.68     1.6     0.24     37.46       12.90     1.9     0.28     50.66       3.53     1.6     0.25     40.85       8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	22	8.90	2.5		0.21	34.77	1 2 3 1 1 1 1					1	1.5
3.68     1.6     0.18     37.87       12.90     1.9     0.28     50.66       3.53     1.6     0.25     40.85       8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	23	4.67	1.9		0.24	37.46				1			2.0
12.90     1.9     0.28     50.66       3.53     1.6     0.25     40.85       8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	24	3.68	1.6		0.18	37.87							2.5
3.53     1.6     0.25     40.85       8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	25	12.90	1.9		0.28	50.66						1	2.0
8.07     1.5     0.21     41.66       78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	26	3.53	1.6		0.25	40.85	1 1 1 1 1 1				1	1	1.5
78.16     2.5     0.27     75.86       139.30     4.2     0.15     74.97	27	8.07	1.5		0.21	41.66	1			1	1	1	1.0
139.30 4.2 0.15 74.97	28	78.16	2.5		0.27	75.86	1						0.5
30	29	139.30	4.2		0.15	74.97	1			1			0.5
31	30					1						1	
	31												

DATE		TURBI	TURBIDITY (FTU)		COAGULANT ALLM	COAG.	FILTER	Al/Fe (mg/L	RES.	Hq	= 5	TEMP.
3	Raw	Set.	Filter	Treat.	1/6m	1/6w	1/6m	Raw Treat	Treat.	Raw Treat	~   -	
-	44.80	3.5		1.10	81.01	1	1				0	
	14.60	2.1		0.45	64.36	1			.	·	0	
3	13.80	2.3	1	0.43	50.89						0	
4	12.70	2.3		0.43	47.75				1		0	
2	20.80	2.1		0.38	66.46						0	
9	19.20	2.6		0.42	52.90						0	
7	14.00	2.0		0.41	55.69	1 1 1 1 1 1 1 1					0	
8	30.90	2.1		0.36	59.77	1 1 1 1 1 1 1 1					0	
6	29.50	2.3	1	0.37	67.55						0	
10	20.30	3.0		0.71	60.85						0	
=	19.20	1.8		0.31	57.79						0	
12	6.80	1.6		0.30	45.13						0	
13	17.20	2.0		0.29	51.64	1 1 1 1 1 1 1					0	
14	9.80	2.1		0.34	44.58	1	1				0	
15	5.13	2.9		0.26	33.14	! ! ! ! !	:				0	0
											-	-

1		TURBIL	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES.	RES.	۵	Ha	TEMP.
NA IF	Raw	Set.	Filter	Treat.	mg/L	mg/L	mg/L	Raw	Raw   Treat.	Raw	Treat.	Raw
16	8.23	2.0		0.20	44.71							0
17	16.08	2.3		0.25	57.99							0
18	27.83	2.1		0.31	75.30	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1					0
19	16.87	2.3		0.30	60.37	1					1	0
50	17.30	2.6		0.35	53.92	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					1	0
21	21.00	2.0		0.31	75.47	1		1				0
22	22.50	2.5	1	0.43	68.23	1						0
23	27.80	3.4		0.73	79.52	1						0
24	29.20	3.8		0.37	66.74				:		-	0
25	15.00	2.6		0.39	63.74			-			1	0
- 26	22.20	2.5		0.52	75.92							0
-27	24.70	3.3		0.38	65.35	1		1				0
28	43.00	2.3		0.29	79.54							1.0
29	. 66.80	3.0		0.32	85.32	1	1					1.0
30	46.80	2.9	1	0.23	73.80						!	1.0
31	19.00	2.6		0.20	58.17							1.0

## TABLE 2.1: PARTICULATE REMOVAL PROFILE

#### MOE WPOS PROTOCOL

APRIL 1984 ·

Raw 17.80 15.70 20.50 24.50 125.80		2.2 2.2 2.2 2.6 2.6 9.5	10kBibliy (FiU) et.   Filter   2.2	Treat.	ALIM mg/L	AID mg/L	AID AID	Ray   Trea	(mg/L) Treat.	Raw	Treat.	Raw L
Ray 17.8 15.7 20.5 24.5 24.5		et	Filter	Treat.	mg/t	mg/L	700	36.2	Ireat.	Kaw	Ireat.	Kaw
17.8		22						101				
20.5		2.6		0.30	67.35	1 1 1 1 1 1			1		1	1.5
24.5		2.1		0.26	46.97	1 1 1	1		.		1 1 1 1	2.0
24.5		9.5		0.20	61.47	1 1 1 1			1		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2.5
125.8		5.6		0.18	55.48	1			1 1 1			2.5
1				0.55	83.47	.1 1 1 1 1		-	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			3.0
25.80		3.7		0.63	77.20	1		1	1			3.0
51.50	<u>!</u>	4.6		86.0	103.09				1		1	3.5
35.80	<u>i</u>	3.3	1	0.30	66.88						1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2.0
38.50	<u>-</u>	4.5	,	1.97	106.07				1		1 1 1 1 1	3.0
43.80	<u>-</u>	2.9		0.26	77.41	1			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1	3.0
31.50	<del> </del>	3.1		0.23	75.20	1 1 1 1 1 1 1				1	1	3.5
35.83	<u>-</u>	3.7		0.37	87.98			-			1	3.5
31.00	<u>-</u>	2.0		0.29	73.14				) 1 3 1 1			4.0
40.33	<u> </u>	2.2	1	0.18	72.31				1			5.0
40.67	<u> </u>	2.8		0.23	74.5	1						5.0

					COACHI ANT	COAC	FILTED	METAI	DFC			TEND
DATE		TURBII	TURBIDITY (FTU)		NIV	AID.	AID	A1/Fe	A1/Fe (mg/L)		F.	(OC)
	Raw	Set.	Filter	Treat.	1/5m	mg/L	mg/L	Raw	Treat.	Raw	Treat.	Raw
16	45.20	2.1		0.19	74.34				1	1		5.0
17	25.70	2.3		0,35	73.00				1			4.5
18	27.00	1.8		0.29	63.56	1						4.5
19	18.00	1.7		0.16	53.32	1						5.0
20	13.90	1.7		0.14	46.36	1						5.0
21	14.10	1.7		0.23	48.72	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						4.5
22	30.40	1.5		0.25	65.72	1 1 1 1 1 1					-	5.0
23	41.00	1.8		0.17	63.70	1 1 1						6.0
24	27.20	2.1		0.13	65.26							5.5
25	10.10	2.3		0.20	61.41				1			5.0
26	14.20	1.8		0.20	45.00	1						5.0
27	12.00	1.8		0.13	21.96			-				5.5
28	12.30	1.4		0.14	47.66	1						7.5
29	8.00	1.6		0.12	31.65						1	5-9-
30	6.70	1.7		0.15	31.04				1			6.0
31												

#### 

Raw         Set.         FIlter         freat.         mg/L         mg/L         mg/L           6.20         2.3         0.13         29.00         1.3         0.18         28.82         1.3         1.4         1.3         1.3         1.4         1.3         1.4	27.40		TURBII	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL Al/Fe	METAL RES. Al/Fe (mg/L)		Hd.	TEMP.
6.20         2.3         0.13           2.90         1.3         0.16           16.80         1.3         0.16           41.80         2.3         0.19           21.70         2.2         0.18           18.00         1.6         0.18           9.70         1.8         0.19           7.48         1.8         0.19           5.18         1.6         0.22           4.07         1.6         0.18           2.43         1.2         0.16           2.53         1.3         0.16           2.53         1.3         0.16	DAIC	Raw	Set.	Filter	1 1	mg/L	mg/L	1/6w	Raw	Treat.	Raw	Treat.	Кам
15.90         11.3         0.18           16.80         1.3         0.16           41.80         2.3         0.19           21.70         2.2         0.23           18.00         1.6         0.18           9.70         1.8         0.13           9.70         1.8         0.19           5.18         1.6         0.22           4.07         1.6         0.18           2.43         1.2         0.17           2.53         1.3         0.16           23.42         2.6         0.19	-	6.20	2.3		0.13	29.00					1	1	6.5
16.80         1.3         0.16           41.80         2.3         0.19           23.80         2.2         0.23           21.70         2.2         0.18           18.00         1.6         0.18           11.30         1.3         0.18           9.70         1.8         0.19           5.18         1.6         0.22           4.07         1.6         0.18           2.43         1.2         0.16           2.53         1.3         0.16           23.42         2.6         0.19	2	2.90	1.3		0.18	28.82			3	· 1			5.0
41.80         2.3         0.19           23.80         2.2         0.23           21.70         2.2         0.18           18.00         1.6         0.18           11.30         1.3         0.18           9.70         1.8         0.19           5.18         1.6         0.22           4.07         1.6         0.18           2.43         1.2         0.17           2.53         1.3         0.16           23.42         2.6         0.19	3	16.80	1.3	1	0.16	41.58				_			5.0
23.80         2.2         0.23           21.70         2.2         0.18           18.00         1.6         0.18           11.30         1.3         0.18           9.70         1.8         0.19           7.48         1.6         0.19           4.07         1.6         0.22           4.07         1.6         0.18           2.53         1.3         0.16           23.42         2.6         0.19	4	41.80	2.3		0.19	34.27	1 1 1 1 1 1					1	5.5
21.70     2.2     0.18       18.00     1.6     0.18       11.30     1.3     0.18       9.70     1.8     0.13       7.48     1.8     0.19       5.18     1.6     0.22       4.07     1.6     0.18       2.43     1.2     0.17       2.53     1.3     0.16       23.42     2.6     0.19		23.80	2.2		0.23	58.56		1					5.0
18.00         1.6         0.18           11.30         1.3         0.18           9.70         1.8         0.13           7.48         1.8         0.19           4.07         1.6         0.22           4.07         1.6         0.18           2.43         1.2         0.17           2.53         1.3         0.16           23.42         2.6         0.19	9	21.70	2.2		0.18	50.05			1	1			6.0
11.30     1.3     0.18       9.70     1.8     0.13       7.48     1.8     0.19       5.18     1.6     0.22       4.07     1.6     0.18       2.43     1.2     0.17       2.53     1.3     0.16       23.42     2.6     0.19	7	18.00	1.6		0.18	59.91				1	1	1	5.5
9.70     1.8     0.13       7.48     1.8     0.19       5.18     1.6     0.22       4.07     1.6     0.18       2.43     1.2     0.17       2.53     1.3     0.16       23.42     2.6     0.19	89	11.30	1.3		0.18	51.46						1	6.5
7.48         1.8         0.19           5.18         1.6         0.22           4.07         1.6         0.18           2.43         1.2         0.17           2.53         1.3         0.16           23.42         2.6         0.19	6	9.70	1.8		0.13	41.92				1			5.5
5.18     1.6     0.22       4.07     1.6     0.18       2.43     1.2     0.17       2.53     1.3     0.16       23.42     2.6     0.19	10	7.48	1.8	1	0.19	41.86				1			0.9
4.07     1.6     0.18       2.43     1.2     0.17       2.53     1.3     0.16       23.42     2.6     0.19	=	5.18	1.6		0.22	53.32				1		1	6.0
2.53 1.3 0.16 23.42 2.6 0.19	12	4.07	1.6		0.18	27.55			1				7.0
2.53 1.3 0.16 23.42 2.6 0.19	13	2.43	1.2	1	0.17	47.75			 				7.0
23.42 2.6 0.19	14	2.53	1.3	1	0.16	25.87						1	6.5
	15	23.42	2.6		0.19	40.84	1						0.9

TABLE 2.1 (cont'd.)

DATE.		TURBIO	TURBIBITY (FTU)		COAGULANT	COAG.	FILTER	METAL Al/Fe	METAL RES. Al/Fe (mg/L)		H	TEMP. (oc)
	Raw	Set.	Filter	Treat.	1/5w	mg/t	1/6w	Raw	Treat.	Raw	Treat.	Raw
	32.63	1.8		0.18	49.47	1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					6.5
!	3.70	1.8	1	0.16	27.33	1 1 3	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			-		8.0
!	2.28	1.4	! ! ! !	0.17	18.76	! ! ! ! !		-	-			6.0
:	2.72	1.5		0.23	24.63			1		-		7.0
!	2.70	1.7		0.14	21.24			-		-		7.5
!	2.30	1.6		0.16	20,39					-		7.5
22	1.80	1.5		0.20	13.43	1 1 1 1 1			1	-		7.5
23	2.40	1.3		0.15	21.59	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1	-			1	8.5
24	1.80	1.2		0.15	16.78	1					-	8.5
25	1.80	1.2		-0.19	15,32	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					-	3-5
26	2.20	1.1		-0,18	19.04							0-6-
27	1.60	1.2		0.15	17.02						1	6r0f
28	9.40	1.1	1	0.16	28.50	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						6-6-
29	68.00	2.9		0.19	64.83	1		-			-	6-8-
30	42.00	2.4		0.17	65.40			1				8.0
31	18.80	1.9		0.18	50.21							8.0

TABLE 2.1: PARTICULATE REMOVAL PROFILE JUNE 1984

Raw         Set.         Filter         Treat.         mg/l         mg/l         Raw         Treat.         Raw         Treat.           7.30         2.8         0.24         20.70         mg/l         mg/l         Raw         Treat.           7.30         2.8         0.24         20.70         mg/l         Ray         Treat.           6.80         1.6         0.26         40.75         Ray         Ray         Ray         Ray           4.60         1.5         0.19         33.88         Ray	DATE		TURBIC	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES. Al/Fe (mg/L)	ā		TEMP.
7.30         2.8         0.24         20.70           6.80         1.6         0.15         33.88         6.15           4.60         1.3         0.15         24.07         6.15           2.50         1.3         0.15         22.15         6.21           2.50         1.4         0.15         25.15         6.21         11.29           3.43         1.6         0.21         11.29         6.21         11.29         6.21           2.04         1.4         0.21         25.85         7         6.24         7           2.04         1.4         0.19         25.66         7         8         8           2.11         1.5         0.19         19.73         8         8         8         8           2.11         1.5         0.19         23.05         8         8         8         8           2.11         1.5         0.19         23.05         8         8         8         8           2.15         1.4         0.19         23.05         8         8         8         8           2.15         1.4         0.19         23.48         8         8         8		Raw	Set.	Filter	Treat.	mg/L	mg/L	J/Bw	Raw Treat	Raw	Treat.	Raw
6.80         1.6         0.26         40.75            4.60         1.5         0.19         33.88            3.00         1.3         0.15         24.07            2.50         1.4         0.15         25.15            2.50         1.4         0.15         25.15            3.43         1.6         0.27         21.01            3.10         1.5         0.21         25.85            2.04         1.4         0.18         25.66            2.10         1.4         0.19         19.73            2.10         1.4         0.19         23.05            2.10         1.4         0.19         23.05            2.10         1.4         0.19         23.05            2.15         1.4         0.19         23.05            2.15         1.4         0.19         23.05            2.3         1.4         0.19         23.05            2.3         1.4         0.17         23.48 <th></th> <th>7.30</th> <th>2.8</th> <th></th> <th>0.24</th> <th>2 α 70</th> <th>1</th> <th></th> <th></th> <th></th> <th></th> <th>8.0</th>		7.30	2.8		0.24	2 α 70	1					8.0
4.60         1.5         0.19         33.88           3.00         1.3         0.15         24.07         8.00           2.50         1.4         0.15         25.15         8.00           3.43         1.6         0.27         21.01         8.00           3.10         1.5         0.21         25.85         8.00           2.04         1.4         0.18         25.66         8.00           2.10         1.4         0.19         23.05         8.00           2.05         1.4         0.19         23.05         8.00           16.90         3.0         0.17         53.48         8.00           23.00         2.0         0.16         51.47         8.1.47	2	6.80	1.6		0.26	40.75			-			10.0
3.00       1.3       0.15       24.07         2.50       1.4       0.15       25.15         3.43       1.6       0.21       11.29         3.10       1.5       0.21       21.01         2.04       1.4       0.18       25.66         2.10       1.4       0.19       19.73         2.05       1.4       0.19       23.05         16.90       3.0       0.17       53.48         15.00       2.0       0.16       51.47	3	4.60	1.5		0.19	33.88	1					9.0
2.50       1.4       0.15       25.15         2.50       1.5       0.21       11.29         3.43       1.6       0.27       21.01         3.10       1.5       0.21       25.85         2.04       1.4       0.18       25.66         2.10       1.4       0.19       23.05         2.05       1.4       0.19       23.05         2.35       1.4       0.19       23.05         16.90       3.0       0.17       53.48         16.90       2.0       0.16       51.47	4	3.00	1.3		0.15	24.07	1					11.0
2.50       1.5       0.21       11.29       8.34       1.6       0.27       21.01       9.21       22.85       9.21       22.85       9.21       22.85       9.21       22.85       9.21       22.85       9.21       9.24	2	2.50	1.4		0.15	25.15		1				10.5
3.43     1.6     0.27     21.01       3.10     1.5     0.21     25.85       2.04     1.4     0.18     25.66       2.10     1.4     0.19     23.05       2.35     1.4     0.19     23.05       16.90     3.0     0.17     53.48       23.00     2.0     0.16     51.47	9	2.50	1.5		0.21	11.29						10.0
3.10         1.5         0.21         25.85         8.66         8.66         8.66         8.66         9.18         25.66         9.18         25.66         9.18         25.49         9.19         9.73         9.19         9.73         9.74	7	3.43	1.6		0.27	21.01						10.5
2.04         1.4         0.18         25.66         6           2.11         1.5         0.19         19.73         8           2.10         1.4         0.17         22.49         8           2.35         1.4         0.19         23.05         8           16.90         3.0         0.17         53.48         8           23.60         2.0         0.16         51.47         8	8	3.10	1.5		0.21	25.85	i 				1	11.0
2.10         1.5         0.19         19.73         8         19.73         8         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.73         19.50         19.73         19.73         19.74	6	2.04	1.4		0.18	25.66	1 1 1 1 1 1 1				1	9.0
2.10         1.4         0.17         22.49           2.05         1.4         0.19         23.05           2.35         1.4         0.23         21.50           16.90         3.0         0.17         53.48           23.00         2.0         0.16         51.47	10	2.11	1.5		0.19	19.73	f f 1 1 1 1 1 1					10.5
2.05         1.4         0.19         23.05         1.50           2.35         1.4         0.23         21.50         1.6.90         3.0         0.17         53.48           15.30         2.0         0.16         51.47         1.	=	2.10	1.4		0.17	22.49	1 1 1 1 1 1 3					10.5
2.35         1.4         0.23         21.50           16.90         3.0         0.17         53.48           23.00         2.0         0.16         51.47	12	2.05	1.4		0.19	23.05	1 1 1 1 1 1 1 1					10.0
16.90     3.0     0.17     53.48       23.00     2.0     0.16     51.47	13	2.35	1.4		0.23	21.50						9.0
23.00 2.0 0.16 51.47	14	16.90	3.0		0.17	53.48			<del> </del>			11.0
	15	23.00	2.0		0.16	51.47						11.0

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DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG. AID	FILTER   AID	METAL RES. Al/Fe (mg/L	RES. (mg/L)	НД		(oc)
	Raw	Set.	Filter	Treat.	1/6w	mg/L	mg/L	Raw	Raw Treat.	Raw	Treat.	Raw
16	4.30	2.0		0.18	16.77							12.0
17	5.00	2.1		0.25	13.54							10.5
18	4.80	2.4		0.30	16.69							10.0
19	7.70	3.6		0.31	35.74							13.0
20	10.80	1.4		0.19	40.87							15.0
21	4.30	1.5		0.16	31.81	1			1	·		14.5
22	4.40	1.3		0.19	32.18							16.0
23	13.30	1.3	1	0.15	33.56							16.0
24	09.6	1.1		0.16	37.56							15.5
25	14.40	-:		0.14	39.48							15.5
26	5.90	1.6		0.12	29.05							16.0
27	1.80	1.2		0.13	96.61			1		· <del>  </del>		7.5
28	2.40	1.3		0.14	24.20	1	1					10.5
29	2.20	1.1		0.15	25.18					<del>-</del>		14.5
30	3.00	1.4	1	0.17	22.73							14.5
- Ε												
								-				

DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES. Al/Fe (mg/L	RES. (mq/L)	됩		TEMP.
5	Raw	Set.	Filter	Treat.	1/6w	1/6w	1/6w	Raw Treat	Treat.	Raw	Treat.	Raw
	3.10	1:1		0.14	28.20				 			14.5
2	3.50	1.3		0.15	21.62						1	14.0
e .	3.10	1.5		0.14	23.81	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		-	1		1	15.5
4	2.60	1.5		0.13	17.91	 			1			14.0
2	2.50	1.5		0.23	32.70	3 5 1 1 1 2 3					1	13.5
9	1.80	1.4		0.15	19.54					<u>i</u>		14.0
	1.80	1.3		0.18	22.24							14.0
8	2.10	1.3		0.12	19.28		1					12.0
6	1.56	1.1		0.16	16.99				1			12.5
101	1.63	1.1		0.19	20.01							9.5
=	2.06	1.1		0.14	27.64				1			9.0
12	1.70	1.0		0.14	21.21				1	i		10.5
13	1.60	1.2		0.23	21.07						1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	11.0
14	1.80	1.6		0.23	25.22	! ! ! ! !						11.0
15	2.00	1.5		0.24	31.56	! ! ! ! ! !	1	1				10.5

TABLE 2.1 (cont'd.)

1	Tubb	VIII) VIII		COAGULANT	COAG.	FILTER	METAL RES.	RES.	Ha		TEMP.
	IOKOI	וחאסוחווו (רוט)	_	ALLM	AID	AID	Al/Fe (mg/L	(mg/L)			(00)
1 1	Set.	Filter	Treat.	mg/L	1/6w	J/6m	Raw	Treat.	Raw	Ireat.	Raw
2.00	1.7		0.21	25.73	1						12.0
1.70	1:1		0.18	22.51	1						11.5
1.50	1.1		0.16	23.29	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					1	12.0
1.50	6.0		0.17	22.44			-				12.0
1.90	1.1		0.20	22.13			:				10.01
1.90	1.2		0.25	19.62				-			11.0
1.90	1.3		0.22	21.41			1				11.0
2.00	1.5		0.16	22.20	1	-					6.5
1.70	1.3		0.21	28.12	1						11.5
1.70	1.6	1	0.56	27.78							13.5
1.60	1.2		0.39	25.12	1						13.0
2.20	1.6		09.0	23.46	1						10:01
2.90	1.7		0.33	35.38	1						10:0
2.10	1.5		0.25	34.26							11.0
2.00	1.5		0.25	36.88							10.0
2.00	1.4		0.36	28.63					<b></b>		16.0
		-									

		THRBI	THRBIDITY (FTII)		COAGULANT	COAG.	FILTER	METAL RES.	RES.	Ha	TEMP.
DATE	RAW	Set	Filter   Treat	Treat.	Mq/L	1/bm	1/bw	Raw	Treat.	Raw   Treat.	~
-	1.90	1.2		0.24	21.53						15.0
-						1 1 1 1 1 1 1 1					
2	1.83	1.0		0.20	28.14	1			. !		16.5
m	2.40	1.3		0.18	13.96	1 1 1 1 1 1 1					16.5
4	1.50	1.3		0.16	17.24	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1				17.5
	1.98	1.6		0.18	18.53		1				19.0
9	1.78	1.6		0.19	22.05	1	1	1	1		18.5
7	1.76	1.2		0.21	22.48						18.0
8	2.45	1.1		0.19	30,75				1		20 A
6	3.77	1.5		0.19	23.88			1			16.0
10	2.77	1.3		0.16	25.38			1	1		19.0
=	6.00	1.2		0.18	34.39		-	1			19.5
12	6.30	1.4		0.17	41.08						19.5
13	5.70	1.0		0.14	39.78	1			1	1	20.0
14	3.20	6.0		0.20	31.25	1	1				20.0
15	3.20	6.0		0.20	30.61						21.5

					COAGIII ANT	COAG.	FILTER	METAL RES	RES.			TEMP.
DATE		TURBI	TURBIDITY (FTU)	_	ALUM	AID	AID	A1/Fe	Al/Fe (mg/L)		E.	(0C)
	Raw	Set.	Filter	Treat.	]/6w	mg/L	1/5w	Raw.	freat.	Raw	Treat.	Kaw
16	2.60	6.0		0.19	27.60							22.5
- 1	18.30	9.0		0.15	. 57.36							22.5
18	5.50	0.7		0.10	36.40						1	21.5
19	17.50	0.8		0.10	43.39							21.0
20	25.70	0.8		0.14	53.94	1					-	19.5
21	09.6	1.0		0.11	33.67	1						20.0
22	00.9	6.0		0.18	34.69						-	20.0
23	6.70	8.0		0.19	31.39		!					19.0
24	12.90	0.8		0.11	51.62		1					19.0
25	00.9	6.0		0.13	38.17	<u> </u>				1		19.0
26	4.70	0.8	1	0.14	34.60			1			1	19.0
12	3.40	0.8		0.12	30.14							19.0
28	3.00	0.7		0.11	30.79			1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		-	18.5
29	2.70	6.0		0.12	38.77			-				18.5
30	2.55	6.0		0.14	23.32							19.0
31	3,26	1.0		0.15	29.12							0.61

## TABLE 2.1: PARTICULATE REMOVAL PROFILE

#### MOE WPOS PROTOCOL

SEPTEMBER 1984

		, adding	VIII.		COAGULANT	COAG.	FILTER	METAL RES.	RES.		Ha	TEMP.
DATE		IUKBII	IUKBIDIIY (FIU)	_	ALLM	AID	AID	A1/Fe	A1/Fe (mg/L)	- 1		(00)
	Raw	Set.	Filter	Treat.	mg/L	1/6w	1/6w	Raw	Ireat.	Kaw	reat.	Kaw
-	3.41	0.8		0.17	30.47							18.5
2	9.38	0.8		0.12	30.90				. !			11.0
m	22.50	0.7		0.14	59.35	1			1		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	14.0
4	31.33	1.0		0.12	66.52	1						USA
	16.45	1.0		0.13	55.56						1	15.5.
9	9.60	1.1	1	0.11	39.15							15.5
7	4.10	6.0	1	0.12	31.56							15.5
	2.50	0.8		0.15	20.07							15,5
6	2.20	6.0		0.16	28.43					-	1	15,0
10	2.20	6.0		0.16	25.48	 			1	1	1	15.0
=	4.40	0.7		0.15	27.34	1					1	15,5
12	6.20	6.0		0.15	26.66							15.0
13	6.20	9.0		0.11	32.63			1				15.0
14	4.00	0.8		0.12	26.47				1			15.0
15	31.80	1.1	1	0.0	43.57							15.0

	TURBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES.	RES.		Ħ	161P.
Set.   Filter	E	e	Treat.	Mg/L	mg/L	1/6w	Raw	Treat.	Raw	Treat.	Raw
1.1			60.0	46.29			1	 	1		15.0
1.7			0.11	42.48	- 1 1 1 1 1 1						14.0
1.6			0.12	42.92	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						14.5
6.0			0.13	37.83	1						15.0
0.7			0.12	38.26							15.0
0.8			0.13	38.31	i						15.0
6.0			0.11	25.76							15.0
0.7			0.16	28.36	1						15.0
0.7			0.16	28.30	- 1						15.0
0.7			0.15	22.27			!	1			15.0
6.0			0.12	43.09	1			1			14.5
1.5			0.15	45.11							14.5
1.6			0.14	50.69	1						14.0
1.2			0.14	30.57				1			13.5
1.0			0.13	32.28				1			14.0

Raw         Set.         Filter         Treat.         mg/L         mg/L           6.55         1.0         0.13         30.35         30.35           8.05         0.8         0.11         29.86           5.91         0.8         0.11         29.86           4.40         0.9         0.11         29.94           17.80         1.0         0.12         32.11           6.50         1.0         0.12         35.27           6.50         1.3         0.13         33.26           5.00         1.6         0.13         30.26           2.50         1.0         0.13         30.26           2.20         1.1         0.13         30.26           2.10         1.0         0.14         25.37           1.90         0.8         0.10         24.74           1.80         0.9         0.09         21.52           1.90         0.9         0.09         21.52	DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	METAL RES Al/Fe (mg/	(mq/L)		Hd	TEMP.
8.05         1.0         0.13           8.05         0.8         0.11           5.91         0.8         0.11           4.40         0.9         0.11           17.80         1.0         0.12           6.50         1.3         0.13           5.00         1.6         0.13           2.20         1.1         0.13           2.10         1.0         0.13           2.10         0.0         0.14           1.70         0.8         0.10           1.80         0.9         0.09           1.90         0.9         0.09		Raw	Set.	Filter	Treat.	mg/L	7/6w	1/6w	Raw	Treat.	Raw	Treat.	Raw
8.05         0.8           5.91         0.8           4.40         0.9           7.90         1.0           6.50         1.3           2.60         1.6           2.20         1.1           1.90         0.13           2.10         0.0           1.70         0.13           1.90         0.8           1.80         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.9           1.90         0.09	-	6.55	1.0		0.13	30.35	1			 			14.0
5.91         0.8         0.11           4.40         0.9         0.11           17.80         1.0         0.10           6.50         1.3         0.13           5.00         1.6         0.13           2.20         1.1         0.13           2.10         1.0         0.13           1.90         0.8         0.10           1.80         0.9         0.09           1.90         0.9         0.10	2	8.05	0.8		0.11	37.99						1	12.5
4.40     0.9     0.11       17.80     1.0     0.10       6.50     1.3     0.13       5.00     1.6     0.12       2.50     1.0     0.13       2.20     1.1     0.13       2.10     1.0     0.14       1.70     0.8     0.10       1.80     0.9     0.09       1.90     1.0     0.09	m	5.91	0.8		0.11	29.86	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1				13.0
17.80         1.0         0.10           7.90         1.0         0.12           6.50         1.3         0.13           2.60         1.6         0.12           2.20         1.1         0.13           2.10         1.0         0.13           1.90         0.8         0.10           1.80         0.9         0.09           1.90         1.0         0.10	4	4.40	6.0		0.11	29.94	1 1 1 1 1						12.0
7.90     1.0     0.12       6.50     1.3     0.13       5.00     1.6     0.12       2.60     1.0     0.13       2.10     1.0     0.13       1.90     0.8     0.10       1.80     0.9     0.09       1.90     1.0     0.09       1.90     0.9     0.09	5	17.80	1.0		0.10	32.11			1	1		 	12.0
6.50         1.3         0.13           5.00         1.6         0.12           2.60         1.0         0.13           2.20         1.1         0.13           2.10         1.0         0.14           1.90         0.8         0.12           1.70         0.8         0.10           1.80         0.9         0.09           1.90         1.0         0.09	9	7.90	1.0		0.12	35.27						1	7.0
5.00     1.6     0.12       2.60     1.0     0.13       2.20     1.1     0.13       2.10     1.0     0.14       1.90     0.8     0.12       1.70     0.9     0.09       1.80     0.9     0.09       1.90     1.0     0.00	7	6.50	1.3		0.13	33,59							7.0
2.60     1.0     0.13       2.20     1.1     0.13       2.10     1.0     0.14       1.90     0.8     0.12       1.70     0.8     0.10       1.80     0.9     0.09       1.90     1.0     0.10	8	5.00	1.6		0.12	29.41							7.5
2.20     1.1     0.13       2.10     1.0     0.14       1.90     0.8     0.12       1.70     0.8     0.10       1.80     0.9     0.09       1.90     1.0     0.10	6	2.60	1.0		0.13	30.26							9.0
2.10     1.0     0.14       1.90     0.8     0.12       1.70     0.8     0.10       1.80     0.9     0.09       1.90     1.0     0.10	10	2.20	1.1		0.13	18.27	_		-				9.5
1.90         0.8         0.12           1.70         0.8         0.10           1.80         0.9         0.09           1.90         1.0         0.10	11	2.10	1.0		0.14	25.37							10.0
1.70 0.8 0.10 1.80 0.9 0.09 1.90 1.0 0.10	12	1.90	0.8		0.12	20.36							9.5
1.80 0.9 0.09 1.90 1.0 0.10	13	1.70	0.8		0.10	24.74							10.5
1.90 1.0 0.10	14	1.80	6.0		0.09	21.52							10.0
	15	1.90	1.0		0.10	19.91							0.6

1	TURBI	TURBIDITY (FTU)		COAGULANT	COAG. AID	FILTER I	METAL RES. Al/Fe (mg/L)	RES.   (mg/L)	Ηď		(oc)
	Set.	Filter	Treat.	1/6w	mg/L	1/6m	Raw	Treat.	Raw	Treat.	Kaw
	1.0		0.11	22.44							8.5
	1.0		0.18	38.72					· -	1	10.0
6.00	1.0		0.14	40.39					· <u> </u>		11.0
5.00	1.2		0.10	43.26				-	·- <del></del>		11.0
4.50	1.1		0.13	25.23	1						11.0
11.00	1.0		0.16	41.15	1			1	· <del>- i</del>		11.0
9.70	1.3		0.12	45.47				1			11.0
6.40	1.2		0.11	34.76				1			11.0
3.40	1.2		0.12	26.10		-					11.0
3.35	1.2		0.14	22.52	1						11.0
11.60	1.2		0.12	43.88							11.9
3.81	1.3		0.14	24.39		1	- <del>-</del>				11.0
4.80	1.3		0.13	32.25							12.0
5.23	1.2		0.13	35.38	1			-			11.5
4.55	1.0		0.12	26.31	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						11.0
17.96	0.8		0.10	45.66							11.0
							•	•	-	•	•

## NOVEMBER 1984 MOE WPOS PROTOCOL

DATE		TURBII	TURBIDITY (FTU)		COAGULANT	COAG.	FILTER	Al/Fe (mg/L	(S. 1	Hd	TEMP.
- -	Raw	Set.	Filter	Treat.	1/5m	mg/L	1/6w	Raw Treat	reat.	Raw   Treat.	Кам
-	21.00	8.0		0.10	36.57		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				11.0
2	23.20	1.1		0.11	44.18				-		10.5
3	16.20	1.0		0.11	43.92	1					9.5
4	12.50	1.2		0.13	41.20	1		. <u>-</u>			12.0
	5.10	1.3		0.12	25.03	1		. <u> </u>			9.5
9	4.10	6.0		0.12	33.09		1				8.5
7	2.50	1:1		0.10	25.22			- <u>-</u>			8.5
9	2.40	6.0		0.12	25.10						8.0
6	2.60	6.0	1	0.11	25.12						8.0
10	2.30	0.0	1	0.14	22.36			!	1		8.0
=======================================	3.50	1:1	1	0.12	25.22						8.5
12	16.70	1.3	1	0.0	48.01				!		7.5
13	28.30	1.8		0.11	51.12						6.0
14	7.50	1.5		0.11	49.22						5.5
15	7.10	1.5		0.11	36.31						5.5
								_			

DATE		TURBI	TURBIDITY (FTU)		COAGULANT	COAG. AID	FILTER	METAL Al/Fe	METAL RES. Al/Fe (mg/L)		нd	(oc)
	Raw	Set.	Filter	Treat.	1/5w	mg/L	J/bw	Raw	Treat.	Raw	Treat.	Raw
91	3.10	1.0		0.11	30.16							0.9
17	2.10	6.0	1	0.09	22.18			1 1		1   1   1   1   1   1   1   1   1   1		5.0
18	1.80	6.0		0.11	20.97					1		5.0
19	4.80	1.2		0.15	31.31							5.0
20	7.10	1.7		0.12	40.20	1 1 1 1 1 1 2	1		1			4.5
21	3.50	1.4	1	0.13	29.50	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				1		4.0
22	4.16	1.5		0.13	26.13	1 1 1 1 1 1				1		3.0
23	2.56	1.1		0.15	30.91	1				1		3.5
24	1.50	1.1		0.14	35.81	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						4.0
25	1.70	1.3	1	0.17	30.29	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			1			4.0
26	1.25	6.0		0.14	16.33	1				1		4.5
27	1.23	0.7	1	0.14	19.20	1					1	5.0
28	1.75	0.7	1	0.15	21.81	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						5.5
29	2.10	0.8		0.13	23.21	1			1			4.0
30	2.90	1.3		0.11	27.13	1				1	1	4.5
31	- <b>-</b>											

# TABLE 2.1: PARTICULATE REMOVAL PROFILE

### MOE WPOS PROTOCOL

DECEMBER 1984

					COAGULANT	COAG.	FILTER	METAL	RES.	_	H	TEMP.
DATE		TURBI	TURBIDITY (FTU)	_	ALUN	AID	AID	A1/Fe (mg/L)	(mg/L)	- 1	2000	(30)
1	Raw	Set.	Filter	Treat.	mg/l	mg/L	1/Em	Kaw	reat.	X D X	ו בפרי	
-	2.40	1.0			24.62	1		1		1	1	5
2	1.50	0.8			20.84			-			1	-4.5
3	9.20	1.1	1		41.45				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			4.5
4	7.20	1.4	1	!	42.33				1 1 1 1		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	3.0
5	4.30	1.3		1	35.58			1				2.5
9	5.00	1.2		1	46.82	-						2.0
7	5.10	1.2			48.00				1			2.0
	3.00	8.0			30.14	1		1	1	-	1	1.5
6	2.00	0.8	-		28.89			1	1			2.0
10	1.60	1.0			17.19			1				2.0
=	1.50	6.0			18.49					-		2.5
12	1.60	1.0			26.76			1				2.0
13	2.20	6.0			20.33						-	3.0
14	31.00	1.1	<u> </u> 		42.84							3.0
15	37.00	1.9			61.87							3.0

Page 2 of 2

SIDITY (FTU) COAGULANT COAG. FILTER	COAGULANT COAG. FILTER	COAGULANT COAG. FILTER	COAG.   FILTER   AID   AID   AID	FILTER   ATD		A1/F	# a.F	METAL RES. Al/Fe (mg/L)	36.0	pH	(oc)
Set. Filter	lreat, mg/L mg/L mg/L	. mg/L mg/L mg/L	mg/ L mg/ L.	1/6w		ž	3	reat.	NOW.		3.0
1.9	69.13	69.13	69.13			į					3.0
81.49	81.49	81.49	81.49		·		Ī			-	4.0
83.98	83.98	83.98	83.98			i					3.0
25.83 2.5	78.84	78.84	78.84			į					2.5
2.1	90.40	90.40	90.40			- !					2.0
3.0	70.05	70.05	70.05			į					2.5
2.0	71.79		67.77			i				-	1.5
2.4	55.86	55.86	55.86			_ [					2.0
1.6	79.53	79.53	79.53			i					1:0
1.4		50.98	86.08		- <del>-</del> -	_ 1					0.5
1.8	65.37	65.37	65.37			_ ;					0.5
2.3	61.75	61.75	61.75			_ !					0.5
2.0	56.52	56.52	56.52			_ 1					3.5
5.4 61.15	61.15	61.15	61,15			;				-	3.5
5.2 90.45	90.45	90.45	90.45								3.0

### TABLE 3

WATER PLANT OPTIMIZATION STUDY "DISINFECTION SUMMARY"

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TABLE 3.0: DISINFECTION SUMMARY (mg/L)

1.35   1.35					1986	91					1985	35		
Hax.   Hin.   Avg.   Hax.   Hin.   Avg.   Hax.   Hin.   Avg.   Hax.   Hin.   Hin.   Avg.   Hax.   Hin.			PRE-	CHI OR IN	TION	P05T-7	HLORINA	NOLL	PRE-	CHLORINA		1-100T	HLORINA	TION
C12 Demand C12 Dosage Aumonta S02 Resid. C12 Free			Max.	Hin.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Hin.	Avg.
Aumonia  Substituting the series of the seri	JAN	Cl2 Demand   Cl2 Dosage			1.00			0.16			1.35			0.22
S02         Resid. C12 free Resid. C12 Comb.         0.25 Comb.         0.19 Comb.         0.45 C12 Comb.         0.10 C12		Ammonta												
Resid. C12 Free (C12 forta)         0.25         0.07         0.19         0.29         0.13         0.21         0.35           Resid. C12 fortal C12 bosage         1.03         0.36         0.36         0.40         0.29         0.11         0.51         0.35           Armonia         Armonia         0.20         0.10         0.18         0.29         0.31         0.13         0.21         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.31         0.32         0.49         0.37         0.31         0.37         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.37         0.31         0.32         0.49         0.33         0.31         0.32         0.32         0.49		S0 <sub>2</sub>												
C12 Demand   1.03   0.12   1.25   1.25		Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.25		0.19	0.45	0.36	0,40	0.29			0.51	0.36	0.42
Name of the color of the colo	FEB	C1 <sub>2</sub> Demand C1 <sub>2</sub> Dosage			1.03			0.12			1.25			0.22
Solution		Anmonta												
Resid. C12 Free State C12 Comb.         0.23         0.10         0.18         0.32         0.49         0.31         0.13         0.22         0.49         0.39         0.37         0.49         0.37         0.49         0.37         0.49         0.37         0.49         0.37         0.31         0.10         0.49         0.37         0.31         0.30         0.37         0.31         0.30         0.37         0.31         0.39         0.37         0.31         0.39         0.36         0.35         0.48         0.16         0.24         0.36         0.36         0.35         0.44         0.16         0.22         0.36         0.36         0.37         0.31         0.35         0.44         0.16         0.24         0.36         0.36         0.36         0.37         0.36		202												
Resid. Ciz Iotal		Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb.	0.23	0.10	0.18				0.31	0.13	0.22			
C12 Demand C12 Dosage C12 Dosage Aumonta S02 Resid. C12 Comb. Resid. C12 Comb. Resid. C12 Total C12 Dosage C12 Dosage C12 Dosage C13 O.35 C.35 C.35 C.35 C.35 C.35 C.35 C.35 C		Resid. Cl <sub>2</sub> Total	-			0.47	0.32	0.40	1	-	1	0.49	0.37	0.39
Cl2 Free 0.37 0.11 0.19 0.66 0.35 0.44 0.16 0.24 0.72 0.36	<b>H</b> AR	Cl <sub>2</sub> Demand Cl <sub>2</sub> Dosage			1.05			0.20			1.37			0.23
C12 Free 0.37 0.11 0.19 0.48 0.16 0.24 0.72 0.36 C12 Iotal		Anmonta												
Cl2 Free 0.37 0.11 0.19 0.66 0.35 0.44 0.16 0.24 0.36 0.35 0.44 0.72 0.35		202				- <b></b>								
C12 Total 0.66 0.35 0.44 0.72 0.36		Resid. Cl2 Free	0.37	0.11	0.19				0.48	0.16	0.24			
		Resid. C12 Total				99.0		0.44				0.72	0.36	0.46

(mg/L
(cont'd.)
3.0
TABLE

APR   C	_						_			1985	٥		
'		PRE-C	PRE-CHLORINATION		POST-C	POST-CHLORINATION	NOLL	PRE-C	PRE-CHLORINATION	TTON	POST-C	POST-CHLORINATION	TION
		Max.	Hin.	۱.	Max.	Min.	Avg.	Max.	H.	Avg.	Max.	E	Avg.
<u>-</u> -	Cl <sub>2</sub> Demand Cl <sub>2</sub> Dosage			1.22			0.21			1.39			0.22
₹	Ammonta												
	502												
~ ~ ~ ~	Resid. Cl2 Free Resid. Cl2 Comb. Resid. Cl2 Total	0.25	0.11	0.17	0.52	0.33	0.40	0.30	0.11	0.20	0.47	0.36	0.42
AY C	C12 Demand C12 Dosage			1.23			0.19			1.45			0.23
	Ammonta												
·	202												
	Resid. Cl2 free   Resid. Cl2 Comb.	0.48	0.10	0.19				0.23	0.12	0.18			
~ !	Resid. Cl2 Total				0.64	0.32	0.41	1			0.45	0.34	0.41
 Mg	Cl <sub>2</sub> Demand Cl <sub>2</sub> Dosage			1.33			0.22			1.72			0.26
<b>-</b> -	Ammonta												
	202												
~ ~	Resid. Cl2 Free	0.23	0.10	0.14				0.23	0.09	0.17			
	Resid. Ci2 Total				0.46	0.35	0.39				0.46	0.35	0.42

PRE-CHIORINATION   POST-CHIORINATION   POST-		_			1986	9					1985	15		
C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand S02  Aumonta  S02  Resid. C12 Tree			PRE-	HLORINA	TION	POST-C	HLORTHA	TION	PRE-C	HLORINA	TION	P05T-C	HI OR I NA	TION
C12 Demand C12 Descape			Max.	Min.	Avg.	Max.	Ηu.	Avg.	Max.	Min.	Avg.	Max.	Ę.	Avg.
Armonta  S02  Resid. C12 free	Ħ	Cl <sub>2</sub> Demand Cl <sub>2</sub> Dosage			2.14			0.29			1.59			0.24
Resid. C12 free   0.14   0.04   0.10   0.43   0.35   0.38   0.21   0.11   0.16   0.47   0.32     Resid. C12 Comb.		Ammonta												
Resid. C12 Free   0.14   0.04   0.10   0.43   0.35   0.38   0.21   0.11   0.16   0.47   0.32   0.35   0.38   0.35   0.3		202												
0.11 0.05 0.08 0.35 0.38 0.32 0.38 0.24 0.08 0.12 0.47 0.32 0.31 0.09 0.04 0.08 0.35 0.39 0.32 0.39 0.32 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.35 0.39 0.39		Resid. Cl2 Free	0.14	0.04	0.10				0.21	0.11	0.16			
C12 Demand C12 Dosage  Armonta  S02  Resid. C12 Comb. C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand C12 Desage  Armonta  S02  Resid. C12 Free 0.01 0.05 0.08 0.25 0.29 0.32 0.24 0.08 0.12 0.46 0.37 0.37 0.28 0.28 0.28 0.38 0.38 0.38 0.38 0.38 0.38 0.38 0.3		Resid. Cl2 Total				0.43	0,35	0.38				0.47	0.32	0.41
Armonia  S02  Resid. C12 Free	AUG	C1 <sub>2</sub> Demand			1.82			0.20			1.94			0.34
Resid. C12 Free   0.11   0.05   0.08     0.25   0.29   0.32   0.24   0.08   0.12     0.46   0.37		Ammonta												
Resid. C12 Free (C12 Comb.)         0.11         0.05         0.08         0.12         0.46         0.37           Resid. C12 Comb.         0.14         0.25         0.29         0.32         0.29         0.32         0.32         0.36         0.37           C12 Demand C12 Dosage Armonia         1.44         0.28         2.20         2.20         0.38         2.20         8.51         0.23         0.07         0.17         8.51         0.35		202												
Resid. Ci2 Total		Resid. Cl2 Free	0.11	0.05	0.08				0.24		0.12			
C12 Demand C12 Dosage Armonta S02 Restd. C12 Free 0.09 0.04 0.06 0.36 0.32 0.32 0.50 0.35		Resid. C12 Total				0.35	0.29	0.32			1	0.46	0.37	0.41
12 Free 0.09 0.04 0.06 0.32 0.07 0.17 0.35 12 Total	SEP	C12 Demand			1.44			0.28			2.20			0.25
12 Free 0.09 0.04 0.06 0.32 0.07 0.17 0.50 0.35 10.01 0.50 0.35		Ammonta												
212 Free 0.09 0.04 0.06 0.32 0.23 0.07 0.17 0.35 0.35 0.09 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35		202												
12 Total   0.36 0.29 0.32   0.50 0.35		Resid. Cl2 Free	0.09	0.04	90.0				0.23					
		Resid. Cl2 Total				0.36		0.32				0.50	0.35	0.42

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PRE-CHIORINATION   PRE-CHIORINATION   POST-CHIORINATION   POST-C					1986	96					1985	35		
Cl2 Demand   Cl2 Demand   Cl2 Desage   L1.72   Cl2 Demand   L1.72   Cl2 Demand   L1.72   Cl2 Demand   L1.72   Cl2 Demand			PRE	CHLORIN	MOLL	P0ST-(	CHLORIN	ATTON	PRE-(	THLORIN/	ATTON	)-TS04	HLORINA	NOLL
C12 Demand C12 Dosage Aumon1a S02 Resid. C12 Comb. Resid. C12 Free C12 Demand C12 Dosage Aumon1a S02 Resid. C12 Free C13 Demand C14 Dosage Aumon1a S02 Resid. C12 Free C15 Demand C16 Demand C17 Demand C18 Demand C19 Demand C19 Demand C10 Demand C10 Demand C11 Demand C12 Demand C12 Demand C13 Demand C13 Demand C14 Demand C15 Demand C15 Demand C16 Demand C17 Demand C18 Demand C19 Demand C19 Demand C19 Demand C10 Demand C10 Demand C11 Demand C12 Demand C12 Demand C13 Demand C13 Demand C14 Demand C15 Demand C15 Demand C16 Demand C17 Demand C17 Demand C18 Desage Aumon1a S02 Resid. C17 Free C18 Demand C19 Demand C19 Demand C10 Demand C10 Demand C10 Demand C11 Demand C12 Demand C12 Demand C13 Demand C13 Demand C14 Demand C15 Demand C15 Demand C16 Demand C17 Demand C18 Demand C19 Demand C19 Demand C10			Hax.	HI.	Avg.	Max.	H.I.	Avg.	Max.	Æin.	Avg.	Max.	Min.	Avg.
Armonta  S02  Resid. C12 Free	100	C1 <sub>2</sub> Demand   C1 <sub>2</sub> Dosage			1.72			0.25			1.54			0.21
Resid. C12 Free   0.12   0.05   0.08     0.42   0.35   0.11   0.19   0.48		Ammonta												
Resid. C12 Free (Cnb. Resid. C12 Comb. Resid. C12 Comb. Resid. C12 Locmb.         0.05         0.08         0.032         0.35         0.11         0.19         0.48           Resid. C12 Demand C12 Dosage         Ammonta         0.07         0.12         0.07         0.12         0.07         0.12         0.05         0.35         0.12         0.16         0.46           Resid. C12 Free Resid. C12 Domand C12 Domand C12 Dosage         0.05         0.03         0.04         0.05         0.05         0.01         0.06         0.10         0.10         0.046           Resid. C12 Domand C12 Domand C12 Dosage         Ammonta         0.05         0.03         0.04         0.05         0.05         0.01         0.06         0.06         0.01         0.046           Resid. C12 Free Resid. C12 Comb. Resid. C12		1 502												
C12 Demand   C12 Demand   C12 Demand   C12 Demand   C12 Demand   C12 Demand   C12 Comb   C12 Comb   C12 Comb   C12 Comb   C12 Demand		Resid. Cl2 Free Resid. Cl2 Comb. Resid. Cl2 Total			0.08	0.42	0.32	0.35	0.25	0.11	0.19	0.48	0.35	0.41
Armonita   S02   S02   S03   S03   S03   S03   S04	NOV	C12 Demand	<u> </u>								1.66			0.24
Resid. C12 Free   0.31   0.07   0.12     0.25   0.35   0.41     0.26   0.12   0.18     0.46     0.12   0.18     0.46     0.12   0.18     0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.12   0.46     0.46     0.47     0		Ammonta												
Resid. C12 Free   0.31   0.07   0.12   0.25   0.35   0.41   0.26   0.12   0.18   0.46   0.12   0.18   0.46   0.12   0.18   0.46   0.12   0.18   0.46   0.12   0.46   0.12   0.46   0.12   0.46   0.12   0.46   0.12   0.46   0.12   0.46   0.18   0.19   0.47   0.47   0.47   0.48   0.18   0.47   0.47   0.47   0.48   0.18   0.47   0.47   0.47   0.48   0.18   0.47   0.47   0.47   0.48   0.18   0.47   0.48		502							- <b></b>					
C12 Demand C12 Dosage Aumonta S02 Resid. C12 Free 0.32 0.14 0.18 Resid. C12 Comb. Resid. C12 Total 0.56 0.32 0.39		Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.31	0.07	0.12	0.55	0.35	0.41	0.26	0.12	0.18	0.46	0.35	0.41
Cl2 Free 0.32 0.14 0.18 0.32 0.39 0.16 0.22 0.32 0.39	DEC	C12 Demand									1.18			0.14
Cl2 Free 0.32 0.14 0.18 0.22 0.39 0.16 0.22 Cl2 Total 0.56 0.32 0.39		Ammonta							- <b></b>					
Cl2 Comb. 0.32 0.14 0.18 0.32 0.39 0.16 0.22 Cl2 Comb. 0.56 0.32 0.39		502							- <b></b>					
C12 Total   0.56   0.32   0.39		Resid. Cl2 Free	0.32		0.18				0.28	0.16	0.22			
		Resid. Cl2 Total				0.56	0.32	0.39				0.47	0.37	0.42

Page 1 of 4

C12 Demand   Hax.   Hin.   Avg.   Haz   Hax.   Hin.   Avg.   Haz					1984	34					1983	33		
Hax.   Hin.   Avg.   C12 Demand   C12 Desage   0.95			PRE-	THE ORTH		POST-	POST-CHLORINATION	NOT I	PRE-C	PRE-CHLORINATION		POST-7	CHLORINA	TION
C12 Demand C12 Dosage  Ammonta S02  Resid. C12 Free Resid. C12 Total C12 Demand C12 Dosage Ammonta S02  Resid. C12 Free Resid. C12 Total C12 Demand C12 Dosage Ammonta S02  Resid. C12 Free Resid. C12 Total Resid. C12 Comb C12 Demand C12 Desage Ammonta S02  Resid. C12 Free Resid. C12 Total Resid. C12 Total C12 Demand C13 Demand C13 Demand C14 Demand C15 Demand C15 Demand C16 Demand C17 Demand C17 Demand C18 Demand C19 Demand C19 Demand C10 Demand C1			Hax.	Hin.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Max. Min. Avg.	Avg.
Armonta  S02  Resid. C12 Free 0.26 0.14 0.20 Resid. C12 Total C12 Demand C12 Demand C12 Desage Armonta S02  Resid. C12 Comb 0.33 0.11 0.18 Resid. C12 Comb Resid. C12 Total C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand C12 Desage S02  Armonta S02  Resid. C12 Free 0.27 0.10 0.17 Resid. C12 Comb 0.27 0.10 0.17 Resid. C12 Comb 0.27 0.10 0.17 Resid. C12 Comb 0.27 0.10 0.17	AN .	Cl <sub>2</sub> Demand   Cl <sub>2</sub> Dosage			0.95			0.15						
Resid. Cl2 Free 0.26 0.14 0.20 Resid. Cl2 Comb. Cl2 Demand Cl2 Dosage Aumonia S02 Resid. Cl2 Free 0.33 0.11 0.18 Resid. Cl2 Total Cl2 Demand Cl2 Demand Cl2 Demand Cl2 Demand Cl2 Demand Cl2 Demand Cl2 Desage Aumonia S02 Resid. Cl2 Free 0.33 0.11 0.18 Resid. Cl2 Total Cl2 Demand Cl2 Dosage Ammonia S02 Resid. Cl2 Comb. Resid. Cl2 Total Cl2 Demand Cl2 Dosage Aumonia		Ammonta												
Resid. C12 Free 0.26 0.14 0.20 Resid. C12 fotal C12 Demand C12 Desand C12 Desand C12 Desand S02 Resid. C12 free 0.33 0.11 0.18 Resid. C12 Comb C12 Demand C12 Demand C12 Demand C12 Demand C12 Demand C12 Desand C13 Desand C14 Desand C15 Desand C15 Desand C16 Desand C17 Desand C17 Desand C18 Desand C19 Desand C19 Desand C19 Desand C10 Desand		502												
C12 Demand C12 Dosage Aumonia S02 Resid. C12 Corb. Resid. C12 Total C12 Dosage C12 Dosage Aumonia S02 Resid. C12 Free C12 Corp. C13 Dosage C14 Dosage C15 Dosage C15 Dosage C16 Dosage C17 Dosage C18 Dosage C19 Dosage C19 Dosage C19 Dosage C19 Dosage C19 Dosage C10		Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total		0.14	0.20	0.45	0.36	0.40						
Armonia  S02  Resid. Cl2 Free 0.33 0.11 0.18  Resid. Cl2 Total Cl2 Deanad Cl2 Dosage Armonia  S02  Resid. Cl2 Free 0.33 0.11 0.18  1.39  Armonia	EB	C1 <sub>2</sub> Demand			1.32			0.27						
Resid. Cl2 Free 0.33 0.11 0.18 Resid. Cl2 Comb. Resid. Cl2 Deand Cl2 Deand Cl2 Dosage Armonia S02 Resid. Cl2 Free 0.33 0.11 0.18 Resid. Cl2 Total 0.17 0.10 0.17 Resid. Cl2 Comb. Resid. Cl2 Total		Ammonta												
Resid. Cl2 Free 0.33 0.11 0.18 Resid. Cl2 Comb. Cl2 Demand Cl2 Dosage Armonia S02 Resid. Cl2 Free 0.27 0.10 0.17 Resid. Cl2 Comb.		202												
C12 Demand C12 Dosage C12 Dosage Armonta S02 Resid. C12 Free 0.27 0.10 0.17 Resid. C13 Comb. Resid. C13 Total		Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.33	0.11	0.18	0.54	0.33	0.41						
Cl2 Free   0.27   0.10   0.17	¥.	C12 Demand C12 Dosage			1.39			0.28						
Cl2 Free   0.27   0.10   0.17   Cl2 Comb.		Ammonta												
Cl <sub>2</sub> Free   0.27   0.10   0.17   Cl <sub>2</sub> Comb.		202												
Clo Total		Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb.	0.27	0.10	0.17				<del>-</del>					
_		Resid. Cl2 Total				0.52	0.19	0.40						

TABLE 3.1 (cont'd.) (mg/L)

				1984	14					1983	33		
		PRE-	PRE-CHLORINATION		1-1204	POST-CHLORINATION	MITON	PRE-C	PRE-CHLORINATION	Г	-TS04	POST-CHLORINATION	HOLL
		Max.	Hin.	Avg.	Max.	Min.	Avg.	Max.	HIn.	Avg.	Max.	M.	Avg.
APR	C12 Demand C12 Dosage			1.37			0.19						
	Ammonta												
	202												
	Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.24	0.11	0.18	0.47	0.33	0.41	 					
¥	C12 Demand			1.58			0.26						
	Ammonta												
	202												
	Resid. Cl2 Free Resid. Cl2 Comb. Resid. Cl2 Total	0.23	0.09	0.15	0.44	0.35	0.41						
N	C1 <sub>2</sub> Demand			1.65			0.28						
	Ammonta												
	202												
	Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.24	0.11	0.16	0.45	0.45 0.34 0.39	0.39						

**TABLE 3.1** (cont'd.) (mg/L)

				1984	14					1983	33		
		PRE-	PRE-CHLORINATION	TION	POST-C	POST-CHLORINATION	ATTON	PRE-	PRE-CHLORINATION	HOLL	P05T-(	POST-CHLORINATION	HOLL
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Ξij.	Avg.	Max.	MIn.	Avg.
301	Cl <sub>2</sub> Demand   Cl <sub>2</sub> Dosage			1.77			0.23						
	Ammonia												
	502												
	Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.21	0.11	0.16	0.44	0.37	0.40				1		1
AUG	C12 Demand			2.13			0.29						
	Ammonia												
	202												
	Resid. Cl <sub>2</sub> Free Resid. Cl <sub>2</sub> Comb. Resid. Cl <sub>2</sub> Total	0.24		0.12	0.45	0.32	0.38						1
SEP	C1 <sub>2</sub> Demand			2.05			0.26						
	Anmonta												
	202												
	Resid. Cl2 Free Resid. Cl2 Comb. Resid. Cl2 Total	0.20	0.08	0.13	0.45	0.36	0.42						
		_	_	_		_	_	_	_				

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		PRF-	PRE-CHLORINATION	T NOT	POST-C	POST-CHLORINATION	NOTT	PRE-C	PRE-CHLORINATION		POST-	POST-CHLORINATION	TION
		Hax.	Hin.	Avg.	Max.	Min.	Avg.	Max.	Min.   Avg.	Avg.	Max.	Min.	Avg.
()	Cl <sub>2</sub> Demand Cl <sub>2</sub> Dosage			1.78			0.29						
- <del>-</del> -	Ammonta												
-   502													
R R R	Resid. Cl2 Free Resid. Cl2 Comb. Resid. Cl2 Total	0.22	0.09	0.18	0.46	0,38	0.43						
NOV   C12	Cl <sub>2</sub> Demand			1.60			0.25						
Amm	Ammonta												
205									_				
Res	Resid. Cl2 Free Resid. Cl2 Comb. I Resid. Cl2 Total	0.28	0.13	0.20	0.50	0.39	0.45						
DEC   C12	C12 Demand			1.39			0.23						
Ame	Ammonta												
205													
Res	Resid. Cl2 Free Resid. Cl2 Comb.	0.29	0.16	0.21									
Res	1d. C12 Total				0.49	0.37	0.43						

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DATE   Dem.   1	C12 Dem. Dos. 1.56 1.16	₹33	\$0,	Free	RESTDUAL C12	Total	51	HN	SOS	¥		27
	1.56	=	7				Dem. Dos.	E	7	ree	Comp.	lota
	1.16	=:		0.22								0.42
	0.83	<u> </u>		0.20					1			0.39
				0.19						-		0.41
	0.49			0.18					1			0.39
	0.71	==		0.20								0.39
	0.87	===		0.20								0.40
	96.0			0.19								0.38
	0.59			0.18								0.36
	99.0	<u> </u>		0.18								0.36
	0.54	===		0.21								0.47
;	1.01			0.22								0.41
	1.50			0.20					1			0.41
	1.22			0.23								0.41
	0.89	===		0.23							1	0.38
	1.04	:=:		0.21								0.36

(mg/L)

	PRE-	PRE- & POST-	L	PRE-CHLORINATION	NAT ION					P03	POST-CHLORINATION	NATION		
DATE	٥	C12	3	S	2	RESTOUAL CI	2	_	12	117	5	2	RESTDUAL CY	2
	Dem.	Dos.	3	200	Free	Comb.	Total	Dem.	Dos.	MH3	2002	Free	Comb.	Total
16		1.27			0.18									0.38
17		1.42			0.22									0.43
81		1.06			0.19							<b>-</b>		0.40
61		1.25			0.21							,		0.37
2		0.70			0.17									0.37
12		1.10			0.19							!	:	0.38
22		1.71			0.18				-			1		0.45
23		0.90			0.07									0,32
24		2.04			0.17									0.43
25		1.11			0.22									0.42
56		1.37			0.18									0.43
27		1.36			0.18									0.38
82		1.24			0.25									0.44
82		0.93			0.22									0.42
30		1.11			0.21									0.40
31		0.87			0.14				<del>-</del>					0.38

FEBRUARY 1986 (mg/L)

0.17   Dem. Dos. 113 3-22   Free Comb. Total   Dem. Dos. 113 3-2   Dem. Dos. 114   Dem. Dos. 1		PRE- & POST-1 C12		PRE-CHLORINATION	NATION	RESTDUAL C12	2	Cl2	2	P08	POST-CHLORINATION	NATION	RESTDUAL C	2
	Dos.		E 3	202	Free	Comb.	Total	Dem.	Dos.	m	205	Free	Comb.	lotal
	0.79				0.17						1	1	-	0.36
	0.61				0.15							1		0.37
0.17 0.19 0.19 0.12 0.22 0.22 0.21 0.18 0.18	0.73				0.16								-	0.36
0.15 0.19 0.17 0.12 0.22 0.21 0.19 0.18	1.10				0.17									0.40
0.19 0.12 0.12 0.22 0.21 0.19 0.19	1.04				0.15									0.38
0.19 0.12 0.22 0.21 0.19 0.19	1.00				0.19									0.38
0.17 0.22 0.21 0.19 0.18	1.25				0.19									0.42
0.12 0.21 0.19 0.18 0.18	1.04				0.17				·					0.44
0.22 0.21 0.19 0.18 0.21	1.28				0.12									0.36
	1.25				0.22									0.44
	0.95				0.21							1		0.39
	0.94				0.19								-	0.39
	1.77				0.18					-				0.40
	0.75				0.21									0.39
	0.65				0.12									0.36

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	PRE-	PRE- & POST-	L	PRE-CHLORINATION	INATION					P08	POST-CHLORINATION	NATION		
DATE	ت -	1,	-	5	2	RESIDUAL CI <sub>2</sub>		2	2	3	5	RE	RESTOUAL CI	2
	Dem.	Dem. Dos.	£	2005	Free	Comb.	Total	Dem.	Dos.	mm3	2002	Free	Comb.	Total
16		1.00	===		0.13									0.40
17		0.87			0.23									0.45
18		1.13			0.21									0.43
61		0.95			0.22									0.39
20		1.14			0.19									0.37
2		0.91			0.19									0.40
22		1.16			0.20									0.44
23		0.56		_	0.19									0.41
24		1.34			0.17									0.39
25		1.12			0.18									0.42
92		1.36			0.13									0.39
27		1.56			0.10								-	0.32
28		1.10			0.22								-	0.47
29			-=-											
30														1
31														
			-	_	_			_				•		

MARCH 1986

Page 1 of 2

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				, N. 11. X. A	1					200	BACT CUI ABTUATION	UATTO		
DATE	PRE-	PRE- & POST- I		PRE-CHLUKINALIUN	INAL ION	RESTRIBIL C	•		(1)		I-CHLUR	RE	RESTBUAL CY	,
1	Dem.	bos.	₩ 3	202	Free	Comb.	Total	Dem.	Dos.	H3	202	Free	Comb.	Total
		1.19			0.18									0.42
2		1.10			0.15									0.35
3		1.40			0.14							-		0.36
4	!	1.39			0.17						1	1		0.40
3		1.15			0.12						1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		0.36
9		0.71			0.18						1	1		0.42
7		0.87			0.15						1	1		0.37
		1.21			0.22									0.57
6		0.83			0.21							1		0.55
2		1.19			0.31							1		0.59
=		1.43			0.11									99.0
12		1.75			0.37									0.61
13		2.03			0.21								-	0.54
14		1.82			0.21								-	0.49
15		09.0			0.21									0.36

TABLE 3.2 (cont'd.)

(mg/L)

	PRF-	PRF- 4 POST4		PRF-CHIORINATION	INATION			L		90d	POST-CHLORINATION	INATION		
DATE		(1)			RES	RESTDUAL C	1	2	12		5	T REA	RESTOUAL CI	2
_	Dem.	l Dos.	£	202	Free	Comb.	Total	Dem.	Dos.	E 33	2005	Free	Comb.	Total
91		1.88			0.17									0.40
- 12	!	1.21		<u> </u>	0.19		 		 - - -					0.41
81	<u> </u>	1.30	<u> </u>	<u> </u>	0.16									0.42
	!	1.63	<u> </u>	<u> </u>	0.14	<del>-</del>								0.37
02	<u> </u>	1.16	<u> </u>		0.18									0.36
21	<u> </u>	1.32	<u> </u>	<u> </u>	0.14									0.41
22		1.55		<u> </u>	0.22									0.39
23		1.40		<u>.</u>	0.27									0.55
24	<u> </u>	1.10			0.23									0.49
	<u> </u>	0.53	<u> </u>	<u> </u>	0.24									0.49
56		0.88	<u> </u>		0.14									0.37
23		1.30	<u> </u>	<u> </u>	0.14									0.37
82		1.18	<u> </u>	<u>.</u>	0.17					_				0.41
59		1.16	<u> </u>		0.19									0.39
30		1.27			0.16									0.40
31	<u> </u>	0.68	<u> </u>	<u> </u>	0.21									0.41

	- 500	PDE - POCT- 1	1	PRF-CHI ORTHATTON	NATION				POS	POST-CHLORINATION	NATION		
DATE	2	C12	Ę	န်	2	RESTBUAL CI	2	2 Dos	£	502	Free	RESIDUAL CI	Total
	nem.	nos.		,	בוננ								
-		0.92			0.20			-			-		0.38
2		0.86	1		0.18							1	0.39
3		1.02			0.22					-		:	0.40
4		1.04			0.21								0.42
5		1.29			0.18								0.41
9		1.25			0.19								0.39
7		1.26			0.21							1	0.40
8		2.05			0.18								0.36
6		1.45			0.17						-		0.42
10		1.53			0.15								0.38
=	<u> </u>	1.15			0.25						1		0.52
12		0.93			0.19								0.33
13		2.41			0.14					- <del>-</del>	1		0.33
14		98.0			0.11						1		0.35
15		1.51			0.19			 					0.40
	-												

(mg/L)

	PRE- & POST-	05141	æ	PRE-CHLORINATION	NATION				PO	POST-CHLORINATION	INATION		
DATE	C12 Dem.   Do		NH3	502	Free	RESTOUAL C	Total	Cl <sub>2</sub> Dem. Dos.	₩ ₩	202	Free	RESTOUAL C Comb.	Total
16	1.	1.39			0.17								0.41
17		1.92			0.13								0.42
18	1.	1.62			0.24								0.46
19	1	1.56			0.15								0.37
50	1,	1.01			0.18								0.36
21	0	0.51			0.18								0.40
- 22	1	1.18			0.23								0.43
23		1.04			0.14								0.36
24	1	1.50			0.13								0.37
52	1.	1.38			0.14								0.41
56	1,	1.35			0.11								0.39
27	1	1.70			0.12								0.40
28	1	1.30			0.15								0.40
59	0	0.75			0.19								0.39
30		1.42			0.16								0.38
31		===											
		-						_	_				

(mg/L)

Page 1 of 2

	DDF - 8	PDF - R POST-1	NA.	PRF-CHIORTNATION	NATTON					POS	POST-CHLORINATION	NATION		
DATE	C12	2	Ę	50,	Free	RESTDUAL C12	Total	Dem.	2 Dos.	₩3	502	Free	RESTOUAL CY	Total
-														75. 0
-	-	1,41		-					-					1
2		1.73			0.16				- <del>i</del>					0.41
		2.07	, —		0.16				- <del>-</del>					0.39
4		1.10			0.48						1			0.64
2		0.51			0.38							1		0.56
9		0.71			0.10				<del>-</del>					0.32
7		1.98			0.16				- <del>-</del>					0.40
8		1.99			0.19				<u></u>					0.43-1
6		1.59			0.20									0.44
10		1.62			0.25									0.41
=		1.48			0.21				- <u>-</u>					0-45
12		1.14			0.23				- <del>-</del>					9.42
13		1.09			0.18									-0.38
14		1.38			0.17				- <del>-</del>					0.39
15		1.28			0.18									0.38

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	PRE- 8 POST+	P0514	L	PRE-CHLORINATION	INATION		F			PO	POST-CHLORINATION	NATION		
DATE	(1)	_	'	5	- E	5	=	<u>၂</u>	ו לוכ	174	5	RE	RESTOUAL C1 <sub>2</sub>	2
	Dem.	m. Dos.	E	202	Free	Comb. To	Total	Dem.	Dos.	E	200	Free	Comb.	Total
16		1.58			0.14		===							0.36
17		1.37			0.21		==	1						0.46
18		96.0			0.17		==							0.40
19		1.46			0.13		===							0.38
20		2.40			0.25							1		0.51
21		2.28			0.17		===							0.35
22		1.65			0.17		===							0.42
23		1.63			0.16		===					1		0.38
24		1.50			0.20		:==							0.43
25		1.07			0.17		===		,					0.40
56		1.25			0.16									0.41
27		1.66			0.15		==							0.42
28		1.43			0.15		==							0.35
59		1.00			0.16							1		0.37
30		96.0			0.13		==							0.37
31		2.30			0.18		===		!	1				0.39
	-	-			-									

	200	1.100	9	DOF - FUL OBTHATION	NATTON					POST-CHL	POST-CHLORINATION		
DATE	- rke- & r	Cl2		2000	RES	RESTDUAL CI	2	1	3	S	æ	RESTDUAL C12	7
	Dem.	Dos.	£	202	Free	Comb.	Total	Dem. Dos.	s.	-	Free	Comb.	Total
-		1.74			0.16								0.37
2		1.87			0.16		1						0.38
m		1.91			0.10		1						0.36
4		2.70			0.23								0.45
5		1.13			0.14								0.37
9		1.78			0.21								0.41
		1.34			0.18	1							0.43
8		1.59			0.13								0.38
6		1.96			0.16								0.40
9		1.17			0.13								0.35
=		1.52			0.13	1							0.38
12		1.71			0.14								0.39
E1 -		1.64			0.15				<del> </del>		· - <del> </del>		0.39
14		2.03			0.14				. <u>-</u>				0.38
15		2.16			0.15								0.39

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	PRF-	PRF- & POST-		PRE-CHLORINATION	NATION					POS	POST-CHLORINATION	NATION		
DATE		(1)			RES	RESTOUAL C12	2	_	2	1	5	RE	RESTOUAL C1 <sub>2</sub>	2
	Dem.	l Dos.	₩	202	Free	Comb.	Total	Dem.	Dos.	3	2002	Free	Comb.	Total
16		2.24	==:		0.16									0.39
17	!	1.14			0.14									0.37
18		1.58			0.13									0.37
19		2.65			0.12									0.40
20	1	1.29			0.14									0.41
21	! ! ! !	1.25			0.12									0.46
22	 	1.89			0.10									0.37
23	1	2.15			0.13									0.42
24		2.01			0.11									0.35
25	! ! !	2.19			0.14									0.40
56		0.97			0.14									0.41
27		1.90			0.12									0.41
53		2.10			0.11									0.40
59		2.06			0.13									0.38
30		1.79			0.12									0.41
31			==											

	144	1300	19	DOC - CUI NOTNATION	MATTAN					04	POST-CHLORINATION	NATION		
DATE	י אני- ביב	PRE- & PUSI-		CHEON	RES	RESTDUAL CT	1		12	1174	5	RE	RESTOUAL C	7
	Dem.	008.	₹	205	Free	Comb.	Total	Dem.	Dos.	MH3	200	Free	Comb.	Total
-		1.83			0.11			==:						0.36
		- 6	-			-		-				1	-	19 0
7		2.33		-	07.0		1			1	-			1
m 		1.68			0.11			==			-			0.40
4		2.05			0.10			==		1 1 1				0.40
2		1.84			0.10			==						0.42
9		2.07	<u>.</u>		0.11		1	:==						0.41
		2.44	<u> </u>		0.10			==						0.38
80	<u> </u>	2.43	<u> </u>		0.08		1	===						0.36
6		2.50			90.0			==		1				0.37
01		2.54			0.08			==						0.38
=	<u> </u>	2.45			0.10			==						0.35
12		2.36			0.14			==						-0.43
13		2.34			0.09			==						0.38
14		2.65		}	0.07		;	==						0.37
15		2.05			0.11			:==						0.40

(mg/L)

TABLE 3.2 (cont'd.)

	PRE- & POST-	P0514		PRE-CHLORINATION	NATION					P03	POST-CHLORINATION	NATION		
DATE	c)	=		5	RES	RESTDUAL CY	2	5	C1 <sub>2</sub>	1	5	RE	RESTOUAL C12	2
	Dem.   D	Dos.		2002	Free	Comb.	Total	Dem.	Dos.	H3	2005	Free	Comb.	Tota
16		2.53			80.0									0.35
17	2	2.65			0.13									0.36
18	3	3.12			90.0									0.36
61	3	3.28			60.0									0.39
2	- 5	2.51			0.12									0.39
21	7	2.63			0.10									0.37
22	2	2.87			0.10									0.37
23	8	3.00			. 80.0									0.38
24	7	1.97			0.10									0.38
25	2	2.56			60.0							_		0.38
56	3	3.77			60.0									0.38
27	2	2.51			0.04									0.35
28	8	3.02			90.0									0.38
29	2	2.56			0.13							1		0.37
90	<del></del>	3.39			0.14									0.37
31	2	2.92	<u>.</u>		0.12		 !							0.38
									1					

TABLE 3.2: DISINFECTION PROFILE

	PRF - A	PRF - A POST-1		PRE-CHLORINATION	INATION					P08	POST-CHLORINATION	NATION		
DATE	ت او	C12 em.   Dos.	₹	202	Free	RESTDUAL C	Total	Dem.	2 Dos.	 ₩	202	Free	RESTOUAL C	Total
-		2.82			0.10									0.34
2		2.67			0.09									0.34
m		3.24			0.08									0.33
4		2.88			0.08						1			0.33
		1.97			0.07									0.30
9		2.36			0.07									0.31
7		2.06			0.07									0.30
80		2.44			90.0									0.29
6		1.94			90.0									0.30
01		2.58			0.05									0.32
=		1.91			0.07									0.32
12		2.17			90.0									0.31
13		2.35			0.07									0.32
14		2.65		,	0.08									0.31
15		1.97			0.11									0.33

(mg/L)

TABLE 3.2 (cont'd.)

	PRE-	PRE- & POST-1	L	PRE-CHLORINATION	INATION					0d	POST-CHLORINATION	INATION		
DATE		-	'-	5	RES	RESTOUAL C	2	ا (1 <sub>2</sub>	2	3	5	RE	RESTDUAL C1 <sub>2</sub>	7
	Dem.	em. Dos.	£	2005	Free	Comb.	Total	Dem.	Dos.	uu3	202	Free	Comb.	Total
9		1.60			0.07									0.32
-		1.51			0.08									0.30
81		1.49	<u> </u>		90.0									0.32
61		1.67	<u> </u>		0.07									0.31
02		2.13			60.0									0.34
23		1.60			0.10									0.33
22		1.89			0.05				·					0.31
23		3.02			0.08				·				1	0.32
24		3.09			0.0				· - <del>·</del>					0.30
52		2.12			0.09				<del>-</del>					0.33
56		2.86			0.09				<del>:</del>					0.31
27		2.77			0.07				·- <del>-</del>					0.33
28		2.99			0.10				·- <del>-</del>		1			0.32
29		1.80			0.07				· <del>·</del>					0.33
30		1.66			0.0									0.35
31		2.28			0.0									0.34

### SEPTEMBER 1986 (mg/L) MOE WPOS PROTOCOL

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C C C C C C C C C C C C C C C C C C C	$\vdash$	PRE- & POST-	OST-11	æ	PRE-CHLORINATION	NATION					PO	POST-CHLORINATION	MAILUM	
2.37 1.52 1.54 1.86 1.82 2.32 2.32 2.30 2.30 2.30 2.30 1.71 1.91 1.91 1.91	DATE		08.	MH3	202	Free	Comb.	Total	Dem.	Dos.	MH3	202	Free Comb.	Total
1.76 1.52 1.84 1.82 2.32 2.20 2.20 2.09 2.09 1.71 1.91 1.91 1.91			.37			60.0								0.29
1.52   1.84   1.82   1.82   1.82   1.91   1.91   1.91   1.91   1.92   1.20   1.76   1.76   1.76   1.76   1.76   1.76   1.76   1.76   1.76   1.72   1.22   1.	2		.76			90.0								0.35
1.54 1.86 1.82 2.32 2.20 2.20 1.91 1.91 1.91 1.71 1.92	<del>!</del>	<del>-</del>	52			90.0								0.32
1.86	<u>-</u>		54			90.0								0.32
1.82	<del> </del>	<u> </u>	.86			0.04								0.31
2.32 1.71 2.20 1.91 2.95 2.09 1.76	<del>-</del>		1.82			0.07								0.32
2.20 1.91 2.95 2.95 1.76 1.76	<del>! -</del> -		2.32			0.07								0.30
2.20   1.91   2.95   1.76   1.22   1.	<del>-</del>		1.71			80.0								0.31
2.95 2.09 1.76 1.76		2	2.20			90.0								0.32
2.09	<del>-</del>	<del>-</del>	1.91			0.07								0.33
1.76		2	2.95			0.05								0.33
1.76			2.09			90.0								0.33
1.22			1.76			90.0								0.33
	<del>!</del>		1.22			0.05							· <u> </u>	0.31
2.21	15		2.21			90.0								0.36

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	PRE-	PRE- & POST4		PRE-CHLORINATION	INATION				P0	POST-CHLORINATION	INATION		
DATE	<u> </u>			2	₩ —	RESTOUAL CT <sub>2</sub>	12		-	5	£	5	_
	Dem.	em. Dos. II	33	2002	Free	Comb.	Total	Dem. Dos.	m <sub>3</sub>	200	Free	Comb.	Total
16		1:11			0.07								0.30
17		1.82			90.0								0.32
81		1.39			0.07								0.33
61		1.76			90.0								0.32
20		2.07			0.07								0.34
21		1.75			90.0								0.32
22		2.13			90.0								0.33
23		1.73			0.04								0.29
24		2.00			0.06								0.31
25		1.68			0.06								0.31
56		1.78			0.07								0.33
27		1.81			90.0								0.32
28		1.58			90.0								0.31
62		1.92			0.07								0.36
98		2.08			90.0								0.31
31													
						_	-	-	_	_	-	-	•

OCTOBER 1986 (mg/L) MOE WPOS PROTOCOL

<u> </u>		PRF - A	PRF- & POST-1	1	PRE-CHLORINATION	NATION					0d	POST-CHLORINATION	INATION		
Dem.         Dos.         M13         3V2         Free         Comb.           1.81         0.05         6.05         6.08         6.08         6.09         6.0	DATE	° 5	-			E	TOWAL C'I	2	٢	12	3	5	2	STDUAL C	2
1.81     0.05       2.16     0.08       2.36     0.08       2.31     0.09       2.41     0.06       2.51     0.06       2.41     0.11       1.54     0.11       1.62     0.08       1.45     0.10       1.62     0.08				£	202	Free	Comb.	Total	Dem.	Dos.	E III	200	Free	Comb.	Total
2.34     0.08       2.36     0.08       2.29     0.09       2.31     0.08       2.41     0.07       1.54     0.10       1.68     0.10       1.62     0.08       1.62     0.08       1.62     0.08	-					0.02									0.32
2.16       2.29     0.08       2.33     0.08       2.46     0.06       2.51     0.07       1.54     0.11       1.68     0.10       1.45     0.08       1.62     0.09       1.62     0.08       1.62     0.08       1.62     0.08	2		2.34			0.08								-	0.35
2.36     0.08       2.31     0.09       2.46     0.06       2.41     0.07       2.51     0.10       1.54     0.11       1.62     0.08       1.45     0.02       1.62     0.08	9		2.16			0.05									0.37
2.29       2.46     0.06       2.41     0.07       2.51     0.10       1.54     0.11       1.68     0.11       1.62     0.08       1.62     0.08       1.62     0.08	4		2.36			0.08									0.35
2.41     0.06       2.41     0.07       1.54     0.10       1.68     0.10       1.95     0.08       1.45     0.08       1.62     0.08	2		2.29			60.0									0.33
2.46     0.06     0.07       2.51     0.10     0.11       1.54     0.11     0.08       1.95     0.08     0.10       1.45     0.08     0.08       1.62     0.00     0.08       1.62     0.00     0.00	9		2.33			0.08									0.33
2.41     0.07     0.10       1.54     0.11     0.01       1.68     0.11       1.62     0.08       1.45     0.08       1.62     0.09	7		2.46			90.0									0.32
2.51     0.10       1.54     0.11       1.68     0.11       1.95     0.08       1.62     0.00       1.62     0.08       1.62     0.08	8		2.41			0.07									0.34
1.54     0.11       1.68     0.11       1.95     0.08       1.45     0.08       1.62     0.08	6		2.51			0.10				i					0.42
1.68     0.11       1.95     0.08       1.45     0.08       1.62     0.10	2		1.54			0.11									0.40
1.95     0.08       1.62     0.10       1.45     0.08       1.62     0.12	=		1.68			0.11									0.36
1.62 0.10 0.08 0.12 0.12 0.12 0.13 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15	12		1.95			0.08							-		0.35
1.45 0.08	13		1.62			0.10									0.36
1.62	14		1.45			0.08									0.34
	15		1.62			0.12									0.35

	PRE-	PRE- & POST-		PRE-CHLORINATION	INATION					POS	POST-CHLORINATION	INATION		
DATE	3	C1 <sub>2</sub>	3	5	RE	RESIDUAL C1 <sub>2</sub>	12	5	2	7	5	- R	RESTDUAL CT?	_
	Dem.	Dos.	E	200	Free	Comb.	Total	Dem.	Dos.	Eun 3	200	Free	Comb.	Total
91		1.51			0.10									0.35
		1.97			0.07				<del>-</del>					0.34
18		2.29			0.10				<del>-</del>	 				0.36
16		2.11			0.08				<del>-</del>					0.32
50		2.14			0.08									0.32
21		1.90			0.09									0.35
22		2.37			0.07									0.36
23		2.41			0.10									0.35
24		1.98			0.11									0.33
25		2.28			0.11									0.37
56		1.92			0.08									0.33
27		0.79			0.11									0.34
28		1.67			0.0									0.36
29		2.00			0.10									0.37
30		1.93			0.09									0.38
31		2.66			0.10				<del>-</del>					0.38
								_	_	_				-

TABLE 3.2 (cont'd.)

Color   Colo		PRE-	PRE- & POST-		PRE-CHLORINATION	INATION					POS	POST-CHLORINATION	NATION		
Dem. Dos.   Mrs 3 302   Free   Comb.   Total   Dem. Dos.   Mrs 3 302	DATE	٥	12	'_	5	R	STDUAL C	2	-	2	3		RE	RESIDUAL C1 <sub>2</sub>	2
1.96   0.10   0.10   0.10   0.10   0.10   0.10   0.10   0.10   0.10   0.10   0.10   0.15   0.15   0.15   0.14   0.25   0.25   0.25   0.15		Dem.	Dos.	=!	200	Free	Comb.	ota	Dem.	Dos.	mm3	-1	Free	Comb.	Total
1.95	16		1.96	===		0.10									0.38
2.27     0.09       1.43     0.15       1.44     0.31       1.32     0.25       1.58     0.06       1.79     0.15       1.39     0.15       1.39     0.16       1.54     0.16	17		1.95			0.10									0.38
1.43   0.15   0.15	18		2.27			0.09									0.40
1.87     0.15       1.59     0.14       1.44     0.25       1.32     0.27       1.58     0.06       1.79     0.16       1.54     0.16       1.54     0.16       1.54     0.16	19		1.43			0.15							1		0.39
1.59   0.14   0.31   1.43   0.31   1.44   0.25   1.32   0.06   1.58   0.06   1.79   0.15   1.39   0.16   1.39   0.16   1.39   0.16   1.39   0.16   1.54   0.13	70		1.87			0.15									0.40
1.43   0.31   0.35   0.25   0.25   0.26   0.06   0.15	21		1.59			0.14				1					0.48
1.44   0.25   0.27	22		1.43			0.31					1				0.55
1.32   0.27	23		1.44			0.25									0.51
1.92   0.08	24	_	1.32			0.27									0.54
1.56   0.06	25		1.92			0.08									0.46
1.59 0.15 0.15 0.15 0.15 0.19 0.16 0.19 0.16 0.19 0.16 0.19 0.16 0.13	56		2.25			90.0									0.52
1.79   0.19   0.19	27		1.58			0.15									0.39
1.39	28		1.79			0.19									0.41
1.54	29		1.39			0.16									0.43
31	30		1.54			0.13									0.38
	31														

	PRE- & POST-	P0ST-11	A.	PRE-CHLORINATION	NATION					POS	POST-CHLORINATION	NATION	RESTRIBLE CTS	
DATE	C 2	(12	É	50,	RES	RESTOUAL C12	Total	Dem.	2 Dos.	MH3	202	Free	Comb.	Total
	Dem.	Dos.		,	2									
-		2.04			0.16									0.41
2	<u>-</u>	1.92			0.19									0.39
		1.77			0.15			!						0.44
4	<u>-</u>	2.41			0.20			!						0.41
5		1.32			0.20					7				0.37
9		1.56			0.15									0.39
7		1.39			0.18						1	-		0.37
8		96.0			0.15									0.39
6		1.20			0.17			=						0.35
10		1.32			0.20					-				0.39
=		1.20			0.18			==						0.38
12		1.23			0.18			==		_				0.39
Ξ		1.92			0.16			==						0.41
7		1.70			0.14			==					-	-0.39
15		1.46			0.24	. <b>_</b> _		==						0.44
	_													

	PRE-	PRE- & POST+1		PRE-CHLORINATION	NATION					POS	POST-CHLORINATION	NATION		
DATE	ں _	- 4		[	E E	RESIDUAL C1 <sub>2</sub>	7	ا داء	2		5	æ	RESTDUAL CY	2
	Dem.	em. Dos. 11	mr3	2005	Free	Comb.	Total	Dem.	Dos.	- F	200	Free	Comb.	Total
91		1.13			0.15									0.40
17	<u> </u>	1.59			0.14									0.37
18		1.48			0.21									0.42
19		1.01			0.20									0.39
2		1.02			0.17									0.36
12		0.83			0.17									0.32
22		1.09			0.19									0.36
23		1.03			0.17									0.33
24		1.03			0.16									0.38
25		1.30			0.16									0.40
92		1.13			0.16									0.37
27		2.41			0.25									0.43
88		2.35			0.32									0.56
62		1.46			0.19									0.41
30		1.15			0.23									0.43
31		0.92			0.17									0.38
	-						-	-		-	-	,	_	

	PRF - A	PRF - A POST - 1	PR	PRE-CHLORINATION	NATION				P05	POST-CHLORINATION	NATION		
OATE	ت: ا	(1)		[	RES	RESTDUAL C12	Ī	1 (1)	1	5	RESTOUAL	5	
	Dem.	Dos.	H3	202	Free	Comb.	Total	Dem. Dos.	mu3	200	Free		Total
-		2.27			0.19								0.37
2		1.77			0.19								0.41
9		2.41			0.18		:						0.42
4		2.22			0.13								0.37
		2.19			0.15								0.41
9		1.83			0.17								0.40
7		2.28			0.19								0.43
8	<u> </u>	1.56			0.21								0.43
6		2.21			0.24								0.45
01		2.00			0.25								0.46
=		2.14			0.26								0.47
12		2.15			0.20								0.45
13		2.00			0.17						<del></del>		0.43
14		2.16			0.19								0.36
15		2.33			0.21								0.44
	-												

	PRE-	PRE- & POST-1		PRE-CHLORINATION	INATION					POS	POST-CHLORINATION	NATION		
DATE	ت -	12	_	03	RE	RESIDUAL C1 <sub>2</sub>	12	<u>ت</u>	12	1	5	RESTOUAL	DUAL CT	_
	Dem.	m. Dos.	E	200	Free	Comp.	Total	Dem.	Dos.	- II3	2002	Free	Comb.	Total
19		1.89			0.29									0.51
12		2.24			0.25									0.45
18		1.32			0.27									0.42
61		1.96			0.25									0.41
50		1.32			0.19									0.39
21		1.45			0.26									0.44
22		1.13			0.29									0.45
23		1.53			0.20									0.42
24		1.63			0.20									0.41
25		1.83			0.18									0.39
56	,	1.53			0.26									0.44
27		1.72			0.19									0.41
28		1.72			0.22									0.42
29		1.75			0.19									0.42
30		1.39			0.23									0.43
31		1.69			0.21				<del>-</del>	 !			<del>-</del>	0.42
								_	-	-	-	-	-	

PRE- & PUSI-11 Cl2 Dem.   Dos. 11	#3 	SO <sub>2</sub>	SO <sub>2</sub> Free	RESTDUAL CI	Total	Dem.	Dos.	NH3	SO <sub>2</sub> Free	Free	RESIDUAL C12 Comb.	Total
1.63			0.25							1		0.47
1.50			0.27							1		0.45
1.33	<del>-</del>		0.22									0.44
1.37	<del>-</del>		0.23							1		0.43
1.68	<u>-</u>		0.23							,		0.45
1.21	<del>-</del>		0.25									0.41
1.21			0.20							1		0.40
1.15			0.20									0.42
1.73			0.13									0.37
1.40			0.19									0.42
1.58			0.17									0.41
1.90			0.17								_	0.41
1.59			0.22									0.41
2.31			0.21									0.47
1.48			0.31			==						0.49

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11 POST-CHLORINATION	Total   Dem.   Dos.   NH3   SO2   Free   Comb.   Total			0.48	0.48	0.43	0.41	0.40	0.37	10.47	0.42	0.41	0.45	10.37			-
PRE-CHLORINATION	13 SO, Free Comb.	0.28	0.30	0.29	0.28	0.21	0.19	0.18	0.19	0.22	0.21	0.14	0.22	0.15			
PRE- 8 POST-1	C12 INH3	. 59	1.37	1.52	1.52	1.53	2.08	1.47	2.27	2.96	2.05	2.23	1.64	2.13			
	DATE			= =====================================	- 62	2		- 22	23	24	- 52	56	27	83	29	90	

DATE C12	PRE-CHLORINATION	THATION					POS	POST-CHLORINATION	NATION		
2.20 1.24 1.14 1.16 1.18 1.160 1.160 1.161 1.161 1.161		E			2	2	3	S	E.	RESTOUAL C12	7
	NH3   3U2	Free	Comb.	Total	Dem.	Dos.	2	202	Free	Comp.	Total
		0.17							1		0.42
		0.48									0.58
		0.31									0.46
		0.31									0.45
		0.18									0.36
	1	0.25									0.48
		0.24									0.51
		0.24							1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		0.48
<del></del> -		0.19									0.38
<del> </del>		0.27									0.42
	 	0.19									0.38
12 2.50		0.22									0.46
13 1.54		0.31									0.49
		0.28									0.49
15 1.58		0.25									0.45

PRE- & POST-4 C12	_'_	岩	INATION	RESTOUAL CT2	2	<b>—</b>		202 -	POST-CHLORINATION	NAT ION	RESTOUAL CT <sub>2</sub>	
Dos.	E	3   302	Free	Comb.	lota	Dem.	Dos.	E	202	Free	Comb.	ota
1.37	12		0.30				:					0.58
0.91	==		0.26									0.64
1.36	98		0.21									0.72
1.30	 e		0.18									0.40
1.64	4		0.23									0.44
1.51	===		0.18									0.37
1.85	55		0.22									0.36
1.76	.76		0.16									0.38
1.65	ارة 		0.22									0.46
2.02	5		0.21									0.44
1.38	<u> </u>		0.18									0.41
1.74	4		0.19									0.42
1.64	4		0.19									0.45
3.18			0.29									0.53
1.63	π		0.18									0.39
1.50	0		0.32									0.45

	- 1200 % - 300 T	1-120d	æ	PRE-CHLORINATION	NATION					200	POST-CHLORINATION	NATION	RESTRUME C	-
DATE	C)2		₹	502	Free	RESIDUAL C12	Total	Dem.	Dos.	₹3	202	Free	Comb.	Total
	nem.				31.0									0.43
-		1./4	-		OT:0				-					
2		1.81			0.22		1	==					1	1,45
3		1.98			0.16			==						0.41
4		1.46			0.16			==						0.38
		1.92			0.20			==				- !		0.36
9		2.92			0.20			==			_			0.45
		2.04			0.17			==						0.44
-		2.32			0.16			==			_			0.39
6		1.97	<u> </u>		0.18			==			_			0.41
2	<u></u>	1.29	<u> </u>		0.19			==						0.38
=		1.23			0.21			==						0.45
15		1.54			0.23		!	==				<u> </u>		-0.431
12		1.72			0.26			==		-				-0.44
14		1.62			0.26			==	_ !					-0.44
15		1.59	<u> </u>  :		0.30			==						0.47
_	-													

	- 100	DDF- & DOST-		DRF-CHIORINATION	MATION					204	POST-CHLORINATION	MATION		
DATE	ا	c1,		5	T RES	RESTOUAL C12	2	(1)	2	1	5	E.	RESTOUAL C12	7
	Dem.	Dos.	£	2002	Free	Comb.	Total	Dem.	- Sol	ш,	200	Free	Comb.	Total
91		1.43			0.30	-								0.47
1-1	!	1.23			0.24									0.43
18		1.32			0.26									0.42
19	! ! !	1.46			0.23									0.40
20		1.31			0.25									0.43
2		1.18	<u> </u>		0.24									0.46
22	; ; ; ;	1.51			0.20									0.43
23		1.57			0.24						_			0.45
24		1.24			0.20									0.39
25		1.72			0.14									0.38
56		1.87			0.19									0.44
27		1.25			0.16									0.39
83		1.04			0.14									0.36
59		1.72			0.11									0.42
æ		1.65			0.16						1			0.41
æ														
									-					

	9	1300	99	BBE - CUI DOTNATION	NATTON					POS	POST-CHLORINATION	INATION		
-	PRE- &	PKE- & PUSI-I		בינורטעו	70	DESTRIBATIONS	9	2	112		1	RES	RESTDUAL C	2
DATE	C 2	2	¥	202	Free	Comp.	Total	Dem.	Dos.	MH3	202	Free	Comb.	Total
-		<u> </u>			0.14									0.40
-														0.40
2		1.66			0.13	-		-			-			
~		1.63			0.18			==	-		1			0.45
4		1.81			0.17									0.40
- 2		1.66			0.19									0.43
9		1.53	<u> </u>		0.18									0.41
		1.59	1_		0.14	<u> </u>								0.37
.   •		6	-	-	0.15			==						0.40
	1			-	31.0		-	<u> </u> ==	<u> </u>				1	0.42
9	-	2.02	-		07.0		1	<u> </u>			-		<u> </u>	0.42
<b>2</b>		1.77	_	_	0.20			==						
=	-	1.53			0.18	_		==				-	-	0.45
-12	<u> </u> _	1.04	<u> </u>	<u> </u>	0.20			-==				-	_	0.42
<u> </u>	<u> </u>	1.45		<u> </u>	0.20									0.43
1	<u> </u> _	1.59	<u> </u>	<u>.</u>	0.17			==						0.39
15	<u> </u> _	1.93	<u> </u>	<u> </u>	0.19	<u> </u>		==						0.42
_	_		_					=						

TABLE 3.2 (cont'd.)

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	PRE-	PRE- & POST+		PRE-CHLORINATION	NATION				ĬŽ.	POST-CHLORINATION	INATION		
DATE		cı,			RES	RESTDUAL CY	2		19	٤	RES	RESIDUAL CI2	_
	Dem.	Dos.	H3	200	Free	Comb.	Total	Dem. Dos.	E 13	200	Free	Comb.	Total
16		1.43			0.23								0.44
17		1.22			0.21								0.38
18		0.91			0.18								0.41
19		1.84			0.16								0.40
50	! !	2.52			0.20								0.40
21		2.42			0.13								0.38
22	!	2.79			0.18								0.43
23		2.58			0.19								0.45
24		1.94			0.12								0.41
25		1.59			0.19								0.38
52		1.70			0.21								0.41
27		1.85			0.21								0.41
83		1.23			0.15								0.42
53		1.15			0.20								0.41
8		1.22			0.22								0.40
31	<u> </u>	1.74			0.16								0.34

(mg/L)

ſ	200	1300		BBC - CUI DB THAT TON	THATTON					POS	POST-CHLORINATION	NATION		
	- FR-	PRE- & PUSI-1		ברוורסא	No.	RESTRUME C		-	2		3	RE	RESTDUAL C12	2
	Dem. De	905.	₩	202	Free	Free Comb.	Total	Dem.	Dem.   Dos.	MH3	202	Free	Free Comb.	Total
		2.43			0.18									0.42
12		2.22			0.18							1 1 1 1 1 1 1 1 1 1		0.40
T		2.12			0.17						1			0.40
14		1.94			0.18							1		0.43
15		1.71			0.20							1		0.41
وا		2.13	<u> </u>		0.23									0.44
		3.17		<u> </u>	0.23							1		0.44
		1.35		<u> </u>	0.22									0.45
6		0.92	<u> </u>	<u>.</u>	0.15									0.39
													_	

7 - 0.43

0.41

0.39

0.44

0.15

0.14 0.21 0.13

1.70 2.86

1.27

0.11 0.17

1.80 2.40 3.05

2

12 13

0.34 0.41

C12 Dem.   Dos.			X.A.Y	WELL A		-					A LIVERY	
2.7	= =	  202	Free	KESTUUAL CI	Total	Dem.	12 005.	H3	202	Free	Comb.	Total
2.7	:=:											
2.2	- <del>-</del> -	 	0.16				-	-				0.42
1		 	0.14									0.42
2.02	5		0.10									0.39
2.06	-==		60.0									0.35
1.85	-==	 	0.09									0.42
2.50			0.18									0.43
2.05	-	 	0.17									0.42
2.20		 	0.20									0.46
2.66	ا و		0.16									0.45
2.07			0.19									0.46
1.68	===		0.25									0.46
2.05	2		0.18									0.44
1.75	ري -		0.18									0.44
1.67			0.14									0.40
1.53	<u>س</u>		0.18									0.44
	==											

Mtg   SO <sub>2</sub>   Free   Comb.   Total   Dem.   Dos.   Mtg   SO <sub>2</sub>   Free   Comb.   Total   Dem.   Dos.   Mtg   SO <sub>2</sub>   Free   Comb.   Total   Dem.   Dos.   Mtg   SO <sub>2</sub>   Free   Comb.   Dos.   Dos.		PRE- 8	PRE- & POST- !	NA.	PRE-CHLORINATION	NATION					PO	POST-CHLORINATION	NATION	1 1	
2.08     0.21       2.13     0.11       1.92     0.16       1.45     0.19       1.67     0.16       2.18     0.19       1.67     0.16       2.30     0.16       2.38     0.11       2.74     0.15       2.39     0.11       2.74     0.12       2.74     0.12	ш	2	Pos		202	Free	Comb.	Total	Dem.	Dos.	NH3	202	Free	RESIDUAL C	Total
2.13     0.11       2.13     0.14       2.13     0.14       1.92     0.16       1.45     0.19       2.15     0.16       1.67     0.19       2.15     0.16       2.26     0.16       2.30     0.15       1.99     0.12       2.74     0.16       2.74     0.16	1		2.08			0.21									0.42
2.23     0.13       2.13     0.14       1.92     0.16       1.45     0.19       1.67     0.18       2.30     0.16       2.30     0.16       2.38     0.11       2.74     0.12       2.74     0.12       2.41     0.11	1		2.13			0.11							 		0.32
2.13     0.14       1.92     0.16       2.71     0.19       1.45     0.19       2.15     0.16       2.60     0.16       2.30     0.15       2.34     0.12       2.74     0.16       2.74     0.12			2.23			0.13									0.40
1.92       0.16         2.71       0.19         1.45       0.19         2.15       0.16         2.30       0.16         2.38       0.11         2.74       0.16         2.74       0.15	1 4		2.13			0.14									0.45
2.71     0.19       1.45     0.19       1.67     0.18       2.15     0.16       2.50     0.16       2.30     0.15       1.99     0.12       2.74     0.11       2.41     0.11	1 9		1.92			0.16					1				0.46
1.45     0.19       1.67     0.18       2.15     0.16       2.30     0.16       2.38     0.11       1.99     0.12       2.74     0.16	10		2.71			0.19									0.41
1.67       0.18       2.15       0.16       2.60       0.16       2.30       0.15       2.38       0.11       1.99       0.12       2.74       0.16	1.		1.45			0.19									0.41
2.15     0.16       2.50     0.16       2.30     0.15       1.99     0.12       2.74     0.11       2.41     0.11	1 8		1.67			0.18									0.42
2.60       0.16       2.30       0.15       2.38       0.11       1.99       0.12       2.74       0.16	16		2.15			0.16									0.40
2.30     0.15       2.38     0.11       1.99     0.12       2.74     0.16       2.41     0.11	10		2.60			0.16									0.40
2.38   0.11 1.99   0.12 2.74   0.16	-		2.30			0.15					1				0.41
2.74 0.16 0.11 0.11 0.11 0.11 0.11 0.11 0.11	1 2		2.38			0.11									0.41
2.74	1 6		1.99			0.12									0.40
2.41			2.74			0.16			-=-						0.43
	1 6		2.41			0.11									0.47

TABLE 3.2 (cont'd.)

Color   Colo	L	PRE- &	PRE- & POST+		PRE-CHLORINATION	NATION					- b0	POST-CHLORINATION	NATION		
Dos.         Mrg 3         372         Free Comb.         lotal         Dos.         33         27         Free Comb.           2.63         0.11         0.12         0.11         0.12         0.11         0.12         0.11         0.12         0.11         0.11         0.11         0.11         0.12         0.11         0.12         0.11         0.12         0.12         0.12         0.12         0.13         0.12         0.12         0.12         0.12         0.12         0.12         0.12         0.12         0.12         0.12         0.12         0.13		ວ່	_	<u>'_</u>	5	22	STOUALC	12	5	7	X	Ş	RE	TOUAL	
0.11 0.12 0.13 0.16 0.16 0.18 0.19 0.19 0.19	اضا	em.	Dos.	_1.	200	Free		Total	Dem.	Dos.		205	ree	COMD.	lota
0.12   0.12   0.11   0.15   0.16   0.16   0.18   0.18   0.18   0.19   0.19   0.19   0.18   0.19   0.19   0.18   0.19   0.19   0.19   0.18   0.19   0.19   0.18   0.19   0.18   0.			2.63			0.11									0.41
0.17   0.11   0.12   0.15   0.15   0.18   0.19   0.	1	<del>-</del> -	1.01			0.12									0.41
0.17 0.18 0.19 0.19 0.19 0.19 0.19 0.19			4.17			0.11									0.41
0.15 0.18 0.19 0.19 0.19 0.19 0.19 0.19			2.69			0.17									0.45
0.17 0.16 0.19 0.19 0.19 0.19 0.19 0.19	I .	<del>-</del>	2.81			0.16									0.40
0.15 0.19 0.19 0.19 0.19 0.18 0.18	1	<del>-</del>	2.56			0.17							-1		0.41
0.18 0.19 0.19 0.19 0.18 0.18	1	<del>'</del>	3.18			0.15									0.40
0.19 0.19 0.19 0.19 0.18	į.		2.07			0.16									0.40
0.19 0.19 0.18 0.18 0.18		<del>-</del>	2.30			0.18									0.43
0.16 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18		<del>-</del>	1.49			0.19									0.40
0.19		<del>-</del>	1.45			0.16									0.41
0.18		<del>-</del>	1.53			0.19									0.41
0.18		<del>-</del>	1.65			0.18									0.36
0.18		<del>-</del>	2.02			0.15									0.38
0.16		<del>-</del>	1.78			0.18									0.39
		 	2.18			0.16	<u> </u>		<u> </u>						0.42

AUGUST 1985 (mg/L)

					THE STATE OF THE S				804	POST-CHLORINATION	NATION	
	PRE- 8	PRE- & POST- !		PRE-CHLORINATION	NATION	BEETINIAL F12		613		5	RESTDUAL C12	2
DATE	٥	C12	ź	20,	roo T	Comb	Total	Dem.   Dos.	- MH3	2n2	Free Comb.	Total
	Dem.	Nos.		7								0.45
_		2.11	_		0.19				-			
-	-				0 17						_	0.43
7		1.68	-		1							0.40
m 		1.23			0.12					1	1	000
4		1.74			0.12					1	1	00.00
	<u> </u>	3 08	<u> </u>		0.00					-	1	0.42
	-		-	-						_	_	0.37
9	_	2.37	_		0.13	-				-	-	0 35
^		2.38			0.08	-					1	
-	<u> </u>			_	0.08				_			0.37
		2:43	-		-				_	_	_	0.41
6	_	2.14	_		0.13	-						
2		1.76	=:		0.10	_		- <del>-</del> -				
=	<u> </u> _	1.53			0.12					_		0.43
12	<u> </u> _		<u> </u>		60.0				_	_		0.40
	<u>.</u>	-7:5	-	<u> </u>		-		- - -	_			0.41
13	_ =	2.90		_			-			<u> </u>		0 42
7		2.81	==	_	0.11			- <del></del>				
15	<u> </u> 	3 07	==		0.09	. — -		 ==				0.40

TABLE 3.2 (cont'd.)

	12	Total	0.40	0.38	0.45	0.41	0.44	0.46	0.43	0.45	0.42	0.44	0.40	0.43	0.40	0.43	0.39	0.40
	RESTDUAL C	Comb.																
NATION	E E	Free						,										
POST-CHLORINATION	٤	200																
8	ā	E																
		Dos.																
		Dem.														===		<u> </u>
	7	Total																
	RESTOUAL CI	Comb.																
NATION	RES	Free	. 60.0	0.08	0.11	0.08	0.10	0.10	0.0	0.24	0.14	0.16	0.21	0.18	0.14	0.14	0.11	0.08
PRE-CHLORINATION	٤	2002																
	1_																	
PRE- & POST+	C12	Dos.	3.49	2.26	1.43	3.40	3.33	3.45	2.49	2.35	3.31	3.10	1.49	1.60	2.84	3.03	2.77	3.28
PRE-	_	Dem.																
	1 DATE		91	17	18	19	2	21	22	23	24	52	56	27	83	53	30	31

	PRE- &	PRE- & POST- !	Ы	PRE-CHLORINATION	NATTON				P08	POST-CHLORINATION	HATION	AI CI'S	
DATE	~	2	Ę	20,		RESIDUAL C	7.04.	Dom Doc	M.	202	Free CO	Comb. Total	-
	Dem.	908			rree	COMID.		-	,	-	十	+	-
		2.87			0.07							0.40	
2		3.68			0.13							0.45	
- m		2.53			0.16							0.42	2
4		2.15			0.14							0.44	4
		2.61			0.19							0.46	9
9		3.17			0.17							0.42	2
		2.98			0.13							0.36	9
		3.20			0.11							0.37	7
6		3.40			0.15							0.46	
2		3.09			0.14							0.38	
=		3.07			0.13			-				0.35	
12		2.34			0.13							0.44	4
13		3.32			0.17						-	0.48	
14		2.18			0.14							0.40	
15		3.15			0.10	. <b>_</b> _						0.41	

TABLE 3.2 (cont'd.)

Γ	PRE-	PRE- & POST-		PRE-CHLORINATION	NATION					P05	POST-CHLORINATION	NATION		
DATE	!	13		5	<b>E</b>	RESTDUAL C	12		ŀ,	3	5	E.	RESTDUAL CT	
_	Dem.	Dos.	- H	202	Free	Comb.	Total	Dem. Do	Dos.	nn3	200	Free	Comp.	Total
16		2.52			0.20									0.42
12		1.91			0.14									0.41
18		2.57			0.19									0.50
19		1.84		    -	0.19									0.41
2		1.30			0.18									0.38
23		2.10			0.14									0.39
22		2.52		<u> </u>	0.21									0.42
23		2.57			0.21									0.41
24		2.53			0.17									0.36
25		2.52			0.21									0.44
92		2.46			0.21									0.45
27		1.89			0.21									0.41
83		1.31			0.20									0.43
62		1.49			0.23									0.47
8		2.42			0.23									0.46
31														
I														

OCTOBER 1985 (mg/L)

MOE WPOS PROTOCOL

												1100		
PATE	PRE-	PRE- 8 POST-1		PRE-CHLORINATION	INATION	RESTOUAL C12	,	5		2	POST-CHLORINATION	NATION	RESTBUAL C12	2
1	Dem.	, Dos.	₩	202	Free	Comb.	Total	Dem.	Dos.	MH3	202	Free	Comb.	Total
1		2.32			0.18					1		1		0.41
2		2.21	<u> </u>		0.20									0.43
m		1.72			0.16							. !		0.44
4		1.79			0.15									0.41
S		2.29			0.15							9 8 8 8 9		0.42
9		2.96			0.20									0.45
7		2.27			0.20									0.48
80		0.69			0.19									0.45
6		2.02			0.22									0.44
10		1.30			0.25									0.42

0.40 0.37

0.22 0.20 0.20 0.19

1.49 1.91

12

1.59 1.89 1.48

-13 7

15

0.21

0.41 0.39

0.43

_	_														·			
	12	Total	0.44	0.39	0.38	0.35	0.38	0.40	0.42	0.41	0.43	0.38	0.38	0.45	0.44	0.43	0.45	0.38
	RESTDUAL C12	Comp.																
NATION	RES	Free						1										
POST-CHLORINATION	٤	200																
POS	1	E I																
	נוי	Dos.																
	_	Dem.																
	_	Total																
	RESTOUAL CT2	Comb.																
NATION	RES	Free	0.22	0.19	0.14	0.11	0.17	0.19	0.22	0.18	0.19	0.18	0.17	0.16	0.18	0.23	0.25	0.18
PRE-CHLORINATION	[	202																
	<u>'_</u>	£		-														
PRE- & POST+	(1)	Dos.	1.68	1.22	1.21	1.45	2.58	1.05	1.29	1.13	1.89	1.80	1.78	1.57	1.29	1.62	1.98	1.83
PRE-	_	Dem.																
	DATE		91	17	18	19	20	21	22	23	24	25	56	27	88	53	30	31

	200	1300	99	DOE - CUI OBTWATION	WATTON					P05	POST-CHLORINATION	NATION	
1	- PR-	PRE- & PUSI-1		ב-נשנים	RES	RESTRUM C13	,	CI		-	8	RESTOUAL	5
DAIL	Dell C	2008.	¥	202	Free	Comb.	Total	Dem.	Dos.	HH3	202	Free Comb.	b. Total
-		1.73			0.20								0.43
2		1.86			0.20			<u> </u>					0.41
		2.75			0.20				<del></del>				0.41
4		1.93			0.26								0.46
5		2.89			0.24								0.41
9		1.14			0.20								0.45
7		3.08			0.20							- 1	0.42
8	<u> </u>	1.95			0.15								0.42
6		2.18			0.20								0.41
2		2.24			0.23								0.46
=		2.42			0.15								0.35
12		1.49			0.19								0.40
13		1.68			0.17								0.38
14		1.76			0.16								0.40
15		2.07			0.16								0.39
	-		_										

è	;	,	
٤	١		
		ı	
		I	
		١	

11 POST-CHLORINATION	RESTOUAL C12   C12   NH3   S02   Free Comb. Total		0.37	0.44	0.40	0.39	0.40	0.36	0.45	0.42	0.38	0.36	0.42	0.43	0.36	0.40	
NATION	RESTOUAL Free Comb		0.16	0.23	0.17	0.15	0.15	0.12	0.23	0.17	0.13	0.12	0.19	0.22	0.14	0.16	_
PRE-CHLORINATION	NH <sub>3</sub> SO,				 			1									
PRE- & POST-1		2.32	1.37	1.30	1.74	2.95	1.87	1.47	1.08	2.46	1.43	1.77	1.52	0.87	0.96	2.11	
	DATE	92	17	82	61	02	2	22	23	24	22	56	22	83	53	8	31

Page 1 of 2

	100	1300	99	DOF - CHI ORYNATION	MATION			L		P03	POST-CHLORINATION	NATION		
	- 78t-	PRE- & PUSI-1		רביוורטו	10	PECTALIAL CIS	,		2		5	RE	RESTDUAL C1 <sub>2</sub>	2
DAIL	Dem.	2005.	₩	202	Free	Comb.	Total	Dem.	Dos.	MH3	202	Free	Comb.	Total
-		1.27			0.17							1		0.43
2		1.65			0.19							1	1	0.40
3		1.44			0.19									0.43
4		1.82			0.16							1		0.41
S		1.92			0.19							1		0.40
9		1.95			0.27									0.45
7		1.54			0.28									0.45
80		1.39			0.23									0.39
6		1.32			0.22									0.40
01		0.91			0.19									0.38
=		1.27			0.21									0.41
12		1.23			0.21	_		==						0.42
13		1.22			0.23									0.43
14		1.11	==	<u> </u>	0.28			==	-		1			0.41
15		0.99	==		0.28			==						0.40
	-	_												

DECEMBER 1985

TABLE 3.2 (cont'd.)

	Total		0.3/	0.47	0.45	0.44	0.40	0.46	0.44	0.45	0.43	0.40	0.40	0.37	0.41	0.40	0.41	0.41
	RESIDUAL C12		-															
MATION	Free																	
POST-CHLORINATION	502	┢-					<del>i</del>	<del>:</del>	<del>i</del>	<del>i</del>	<del>i</del>	<del>i</del>	·- <del></del>		·	·		
POS	₩.		-															
	12 Dos																	
			==			-==	===	:=:					==	==			===	===
	Total			   														
	RESIDUAL C12																	
NATION	RES		0.20	0.24	0.28	0.24	0.19	0.28	0.21	0.21	0.25	0.20	0.27	0.22	0.24	0.18	0.21	0.22
PRE-CHLORINATION	50,																	
	£																	
PRE- & POST-	C12	100	0.54	0.63	0.76	1.35	0.86	1.13	1.15	96.0	1.18	1.15	0.82	1.03	1.38	1.25	1.29	1.16
PRE-	٥		_ :															<u> </u> 
	DATE		16	17	18	19	2	21	22	23	24	25	56	27	83	56	ထ	31

JANUARY 1984 (mg/L)

										) d	BOCT - CHI OD INATION	MATTON		
PATE	PRE-	PRE- & POST-1	*	PRE-CHLUKINALIUN	NALIUM	RESTOUAL C			C12		2	RE	RESTDUAL CT	7
<u> </u>	Dem.	0085	₹3	505	Free	Comb.	lota	Dem.	Dos.	uH3	202	Free	Comb.	Total
		0.93			0.19								1	0.41
2		1.30			0.19								.)	0.41
m		1.23			0.19			-						0.39
4		1.09			0.25						1	. !		0.44
2		0.91			0.25						1			0.44
9		0.82			0.15									0.36
^		1.31			0.22			-						0.42
æ		1.27			0.23									0.41
6		1.10			0.25									0.38
9		1.15			0.22							1		0.38
=		1.17			0.22			==						0.44
12		1.27			0.20			==				1		0,38.
13		0.92			0.17			==						-D.38-
14		1.52			0.20			==						-985-0-

0.45

0.22

1.36

Dos.   NH3							3	1031 CHEOMINALION			
	H	SE SE	RESTOUAL CI	7	٥	(12	¥	S	2	RESTDUAL C12	7
	3   302	Free	Comb.	Total	Dem.	Sos.	E	200	Free	Comb.	Total
		0.18									0.41
<u>!</u>	-	0.14									0.37
==		0.16									0.38
-=-		0.26									0.43
==		0.17									0.40
===		0.16									0.41
==		0.17									0.40
==		0.17									0.40
==		0.14									0.41
==		0.21									0.41
==		0.20									0.38
1.48		0.15									0.39
-=-		0.22									0.45
1.48		0.23									0.40
1.38		0.18									0.42
0.92		0.20									0.41

RESTOUAL

PRE-CHLORINATION 50,

PRE- & POST-1

ree 0.18

₹ ¥

C12 Dem. | Dos.

DATE

(mg/L) FEBRUARY 1984

NATION	Free		1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1									
POST-CHLORINATION	502	,			!						1		
P08	¥ E												
	C12 Dos.												
	ر ا					<u> </u> _	<u> </u>	<u> </u>					-
	C12								!				
1	Ρ.		1 T	1	1	1	1	!	!	:	!	1	

0.19

0.15

0.18

0.15 0.14

1.07

1.18

0.33

1.84 0.87 1.26

1.20

0.20

1.11 1.17 1.08 1.62

2

0.18 0.24 0.15

0.17

1.00

-----

12 13

=

1.35

1

0.17

0.18

2.62

2.51

0.22

0.42

0.43 0.40-0.43 0.37 0.38-0.35 -0.54-

0.41

0.39

Total 0.40

Comb.

	PRF - & POST+		PRE-CHLORINATION	NATION					POS	POST-CHLORINATION	NATION		
DATE	[]			RES	RESIDUAL CT?	2	<b>t</b>	2	-	5	E	RESTDUAL C12	2
	Dem.   Dos.	HH3 -	202	Free	Comb.	otal	Dem.	Dos.	- III3	2005	Free	Comb.	Total
16	12.84	==		0.20							- <b>-</b>		0.45
17	2.55	==		0.33									0.47
188	2.01			0.18				,					0.42
61	11.71			0.16									0.41
50	1.06			0.25									0.47
2	11.19	===		0.15									0.39
22	1.57			0.16							1		0.40
23	1.52			0.13									0.39
24	1.75	:		0.08		_							0.37
25	11.99	===		0.11									0.38
56	1.96			0.23									0.49
27	1.27	===		0.16									0.45
82	1.79	===		0.17									0.40
59	13.03	===		0.21									0.44
99													
31													· <b>-</b> -
		_		_	_	_	_		-				

Page 1 of 2

		Total		0.43	0.52	0.44	0.42	0.42	0.42	0.37	0.32	0.19	0.41	0.42	0.40	-0.39-	-0-34-	0.41
	1000	KESTUUAL C.																
	NATION	Free		-			.							_				
	POST-CHLORINATION	202		-								_		_	_			
	PO	NH <sub>3</sub>						1										
		005.	-														_ <u> </u>	
		- E		<u> </u>	==	==	==	==	==	==	==	==	==	==	==	==	==	==
1000L		Total																
MOE WPOS PROTOCOL		RESTDUAL C																
MOE	NATION	RES	2011	0.18	0.20	0.22	0.22	0.18	0.27	0.14	0.15	0.13	0.10	0.19	0.19	0.18	0.14	0.19
	PRE-CHLORINATION	\$0,																
	ă	Ę																
	PRF- & POST- 1	7	Son Son	1.52	1.60	1.62	1.21	1.15	1.34	1.48	1.74	1.70	2.12	2.06	1.73	2.10	1.50	2.46
	PRF - A	CI,	Dem.															
		DATE		-	2	m	4	S	9	1	6	6	2	=	12	13	14	15

	- 100	PDF- & POST4	PRE-CHIORINATION	NATION				PO	POST-CHLORINATION	INATION		
DATE		5		RES	RESTDUAL C1,		(1)	-	5	T RES	RESTOUAL CY	7
-	Dem.	l bos.	  505	Free	Comb.	Total	Dem. Dos.	E .	200	Free	Comb.	Total
16		2.12		0.15								0.42
12	1	1.31		0.22								0.43
18		1.94		0.20	<del>i</del>		<del> </del>					0.42
19		1.42		0.20	- <u>- i</u>							0.42
20		2.08		0.17			-	. <u>-</u>				0.41
21		1.75		0.10	·- <del></del>							0.41
22		1.49		0.16	· – <del> </del>			<del> </del>				0.39
23		1.88		0.18	<del>-</del>		. <u> </u>	. <u> </u>				0.46
24		1.79		0.16	·		- <u>-</u>	<u> </u>				0.37
25		2.20		0.15			<u>:</u>	<del> </del>				0.40
92		2.23		0.16	·- <del>-</del>				_			0.41
27		2.14		0.18				. <u>-</u>				0.39
82		1.65		0.13	- <del>-  </del>							0.42
62		2.54		0.11			<u> </u>					0.39
98		2.44	 	0.15								0.42
. E		2.20		0.18								0.43
					-	-	-	-	-			

Page 1 of 2

					ž	HUE WILLS TROUGUE	I OCOL							
	PRF - A	PRF - & POST- 1	, d	PRE-CHLORINATION	NATION					POS	POST-CHLORINATION	INATION		
DATE	ີ່ເ	-		[	1	RESIDUAL C12	2	ت ا	C12	¥	20,		RESTDUAL CI	7
	Dem.	Dos.	HH3	200	Free	Comb.	Total	Dem.	Dos.		200	ree	COMD.	lotal
-		1.95			0.15									0.40
2		1.51			0.19									0.43
9		1.60			0.15							-		0.38
4		1.84			0.15									0.36
2		2.33			0.11									0.38
9		2.27			0.27									0.47
7		2.01			0.18									0.44
8		1.90			0.16					-				0.42
6		2.53			0.17									0.47
2		2.05			0.17			_						0.40
=		1.65			0.14			-						0.40
12		1.92			0.19			<u> </u>						0.43
13		1.80			0.21									0.43
14		1.60			0.24									0.46
15		1.91			0.19									0.41
	_	-	_	_										

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TABLE :	TABLE 3.2 (cont'd.)	I	APRIL 1984	1984	(mg/L)							Page	Page 2 of 2
	PRE- & POST-	15150	PR	PRE-CHLORINATION	NATION				PO	POST-CHLORINATION	NATION		
DATE	C12		77	5	<u>S</u>	RESTOUAL CT	7		¥	50,	RES	5	
	Dem. Do	Dos.	2	2005	Free	COMO.	100	nem. nos.	- -	7	3	COMID	100
19	-1-	1.48			0.21								0.37
17	1.	1.35			0.20								0.41
18	2.	2.06			0.15								0.37
19		1.55			0.20								0.41
02	1.	1.53			0.16								0.40
2	1,	1.58			0.21				<del>-</del>	!			0.43
22		1.50			0.19								0.42
23	1	1.51			0.18								0.41
24	1	1.70			0.18				. <u> </u>				0.39
25		1.20			0.17								0.40
56	1	1.66			0.20			<u>i</u>					0.43
27	1.	1.58			0.16								0.33
82	1.	1.56			0.19								0.38
53		1.89			0.20								0.44
33	1	1.64			0.14								0.38
31	_	==	_		-			_					

1984 (mg/L)

MH3   SO2   Free   Comb.   Total   Dem.   Dos.   MH3		PRF- A	PRF - & POST- 1	PRE-CHLORINATION	NATION					04	POST-CHLORINATION	INATION		
1.61     0.11       1.62     0.12       1.94     0.22       1.19     0.22       1.51     0.16       1.51     0.21       1.51     0.18       1.52     0.18       2.20     0.10       1.63     0.10       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12	DATE	Dem.	Pos.	502	RES Free	Comb.	Total	Dem.	2 Dos.	NH3	202	Free	SIDUAL C Comb.	Total
1.62     0.12       1.94     0.22       1.59     0.16       1.51     0.18       2.20     0.18       1.63     0.10       2.20     0.10       1.63     0.10       2.22     0.12       1.63     0.10       2.23     0.10       2.23     0.10       2.23     0.10       2.23     0.12	-		1.61		0.11									0.36
1.49     0.18       1.51     0.22       1.51     0.16       1.51     0.21       1.51     0.18       1.52     0.18       2.20     0.10       2.20     0.10       1.63     0.12       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12	2		1.62		0.12									0.38
1.94     0.22       1.51     0.16       1.51     0.21       1.51     0.21       1.52     0.18       2.20     0.10       1.63     0.10       2.22     0.10       1.63     0.12       2.23     0.12       2.23     0.12       2.23     0.15	9		1.49		0.18									0.40
1.19     0.22       1.51     0.16       1.51     0.18       1.52     0.18       2.20     0.10       1.63     0.12       2.23     0.12       1.63     0.00       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.15	₹		1.94		0.22									0.42
1.59     0.16     0.21     0.21       1.51     0.21     0.18     0.18       1.52     0.18     0.10     0.10       2.02     0.12     0.12       1.53     0.12     0.10       2.23     0.12     0.12       2.23     0.12     0.09       2.23     0.15     0.15	2		1.19		0.22									0.43
1.51     0.21       1.91     0.18       2.20     0.10       1.63     0.10       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.12       2.23     0.15	9		1.59		0.16									0.41
1.91     0.18       2.20     0.10       2.02     0.12       1.63     0.12       2.23     0.12       2.23     0.09       2.23     0.09	7		1.51		0.21									0.41
1.52     0.18       2.02     0.10       1.63     0.10       2.23     0.12       1.98     0.09       2.23     0.15	80		1.91		0.18									0.40
2.20       2.02       1.63       0.10       0.12       0.12       0.12       0.12       0.12       0.12       0.13       0.14       0.09       0.15	6		1.52		0.18									0.42
2.02       1.63       2.23       0.12       0.12       0.12       0.09       0.15	9		2.20		0.10									0.39
1.63     0.10       2.23     0.12       1.98     0.09       2.23     0.15	=		2.02		0.12									0.36
2.23 0.12 0.09 0.15 0.15 0.15 0.09 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.15	12		1.63		0.10									0.35
	13		2.23		0.12									0.41
2.23	14		1.98		0.0									0.39
	15		2.23	 	0.15									0.41

	PRE- &	PRE- & POST4		PRE-CHLORINATION	NATION				P05	POST-CHLORINATION	NATION		
DATE	ב	_	]	5	RE	RESTOUAL CI	2	_	2	5	RES	5	
	Dem.	em.   Dos.	#3	202	Free	Comb.	Total	Dem. Dos.	E	2005	Free	Comb.	Total
16		2.12			0.20								0.42
17		1.51			0.23								0.44
18		1.71			0.17		_						0.44
19		2.00			0.12								0.39
02		2.47			0.09								0.39
21		2.74			0.12								0.38
22		2.05			0.13								0.44
23		2.61			0.14								0.42
24		2,35			0.19								0.42
25		1.86			0.12								0.41
26		1.97			0.21								0.44
27		2.07			0.12							- <del>-</del>	0.41
82		1.86			0.17								0.42
53		1.87			0.19								0.93
30		1.58			0.15								0.42
31		1.70			0.15								0.39

## MOE WPOS PROTOCOL

1.96   NH3   SO <sub>2</sub>   Free   Comb.   Total   Dem.   Dos.     1.96   0.14		DDE - P	DDF - 1 DOCT - 1	ă	PRF - CHI ORTNATION	THATTON					POST-CHI	POST-CHLORINATION		
1.96	DATE		2		5	R	STOUAL CI	7	5	2	NH. SO.		닯	2
1.96     0.14       1.39     0.15       1.47     0.15       1.52     0.15       2.36     0.18       1.72     0.23       1.97     0.22       2.33     0.22       2.34     0.22       2.33     0.22       2.34     0.22       2.37     0.15		Dem.	002	E	202	Free	Comp.	lota	Dem.	nos.	-	Lie	- COMPO	101
1.39   0.15   0.14   0.14   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.15   0.18   0.18   0.18   0.23   0.22   0.23   0.22   0.22   0.22   0.22   0.22   0.22   0.23   0.22   0.22   0.23   0.22   0.22   0.23   0.22   0.22   0.23   0.22   0.23   0.22   0.23   0.22   0.23   0.23   0.22   0.23	-		1.96			0.14								0.38
1.47     0.14       1.48     0.15       1.52     0.15       2.36     0.13       1.82     0.13       1.72     0.23       1.92     0.23       1.92     0.24       2.33     0.22       2.33     0.22       2.34     0.15       2.26     0.15	2		1.39			0.15						<u>!</u>		0.38
1.48     0.15       1.52     0.15       1.97     0.13       1.82     0.13       1.72     0.23       1.92     0.18       1.92     0.24       2.33     0.22       2.33     0.22       2.34     0.15       2.26     0.15	6		1.47			0.14								0.35
1.52     0.15       1.97     0.15       2.36     0.13       1.82     0.18       1.72     0.23       1.97     0.24       2.33     0.22       2.37     0.15       2.36     0.15	4		1.48			0.15								0.34
1.97     0.15       2.36     0.13       1.82     0.18       1.72     0.23       1.92     0.18       1.97     0.24       2.33     0.22       2.37     0.15       2.26     0.15	2		1.52			0.15								0.38
2.36   0.13   0.13	9		1.97			0.15								0.37
1.82     0.18       1.72     0.23       1.97     0.24       2.33     0.22       2.37     0.18	7		2.36			0.13								0.39
1.72   0.23	80		1.82			0.18								0.44
1.92   0.18	6		1.72			0.23						<del> </del>		0.42
1.97   0.24	10		1.92			0.18						. – !		0.38
2.33 0.22 0.22 0.22 0.22 0.23 0.22 0.22	=		1.97			0.24					. <u> </u>		<u> </u>	0.43
2.08 0.22 0.33 0.17 0.15 0.15 0.15	12		2.33			0.22								0.45
2.37	13		2.08			0.22								0.43
2.26	14		2.37			0.17					<u> </u>			0.42
	15		2.26			0.15								0.41

	- 100	DDF - BOOKTA	POF - CHI OR THAT TON	MATION					204	POST-CHI ORINATION	MATTON		
DATE	2	50.50	CHEOR	RES	RESTDUAL C15	_	2	5	3		RES	RESTOUAL CT?	
	Dem.	Dos.	 202	Free	Comb.	Total	Dem.	Dos.	MH3	202	Free Comb.	Comb.	Total
16				0.15									0.38
17		2.30		0.16									0.41
18		08.0		0.19									0.40
16		2.02		0.14									0.39
20		2.02		0.14									0.39
21		2.49		0.12									0.36
22		2.11		0.16							,		0.40
23		2.16		0.13									0.38
24		2.66		0.11									0.36
25		2.91		0.07									0.36
56		3.03		0.16									0.42
27		2.17		0.14									0.39
83		2.57		0.16									0.42
62		2.51		0.18									0.41
90		1.36		0.15									0.38
31											- <b>-</b>		

IMBLE	3.4.				JOH	MOE WPOS PROTOCOL	000							
	PRE- & POST-	P0ST-11	ă	PRE-CHLORINATION	THATION					P0	POST-CHLORINATION	INATION		
i OATE	C12 Dem.	2 Dos. 11	NH3	502	Free	RESIDUAL C12	Total	Dem.	12 Dos.	₩ 3	202	Free	Comb.	Total
		1.80			0.15									0.38
2	<u> </u>	1.81			0.19									0.41
m		2.00			0.13									0.38
4		2.46			0.17				-		_			0.40
		2.01			0.19									0.41
9		1.99			0.19					-				0.42
		2.24			0.18				-					0.40
<b>6</b>		2.27			0.16									0.40
6		1.92			0.19									0.43
2		1.95			0.17									0.37
=		2.31			0.17									0.39
12		1.75			0.14									0.39
13		1.79			0.15	-								-0.43-
4		2.42			0.21			==					_ <u> </u>	

0.42

0.15 0.21 0.16

2.42 1.79

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JULY 1984

	PRE-	PRE- & POST-		PRE-CHLORINATION	INATION					P05	POST-CHLORINATION	NATION		
DATE	=			5	RE	RESIDUAL CI	2	2	7	3	5	<b>8</b>	RESTDUAL C	2
	Dem.	em. Dos.	33	2005	ree	Comb.	Total	Dem.	Dos.	mm3	200	Free	Comb.	Total
16		2,35			0.16									0.39
17		1.83			0.13				<del>-</del>					0.39
18		2.38			0.11				<del>-</del>					0.37
19		2.41			0.13				<u>-</u>					0.40
20		2.09			0.13	 			<del>-</del>					0.38
2		2.21			0.16									0.41
22		2.15			0.14		1							0.40
23		2.04			0.15									0.41
24		2.55			0.16									0.40
25		2.20			0.19									0.44
56		2.19			0.16									0.39
27		2.54			0.17									0.40
83		2.33			0.16									0.39
59		2.13			0.16									0.39
30		2.03			0.17									0.43
31		1.86			0.15							! !		0.38

# AUGUST 1984 (IIII) L)

MOE WPOS PROTOCOL

raye 1 of 2

	- 300	PRE- & POST- 1	1	PRF-CHIORINATION	NATTON					-0d	POST-CHLORINATION	INATION		
DATE	<u>ن</u> د	3			¥	RESIDUAL CI	_	2	CI <sub>2</sub>	3	5	E.	RESTDUAL CT	2
5	Dem.	em.   Dos.	NH3	202	Free	Comb.	Total	Dem.	Dos.	E#3	202	Free	Comb.	Total
-		1.76			0.13									0.38
2		3.16			0.18									0.39
3		2.14			0.24									0.39
4		1.61			0.18							1		0.38
2		2.02			0.16									0.37
9		2.07			0.18							,		0.36
7		2.61			0.11									0.32
80		1.88			0.13									0.35
6		2.33			0.14									0.40
2		2.96			0.12									0.37
=		2.57			0.12									0.37
12		3.22			0.13									0.37
13		1.89			0.12									0.35
14		2.81			0.11									0.33
15		3.05			0.13			:==				1		0.37

	PRE-	PRE- & POST-1		PRE-CHLORINATION	NATION					204	POST-CHLORINATION	NATION		
DATE	5	(1)		3	RES	RESTOUAL CT	2	ا <del>دا</del> 2		170	5	RESTOUAL	AL C12	_
	Dem.	Dos.	MH3	202	Free	Comb.	Total	Dem.	Dos.	- E	200	Free Co	Comb.	Total
91		2.61			0.05									0.33
17		3.09			0.07			<u></u> -						0.44
18		2.76			0.08									0.45
61		3.93			0.14									0.42
02	1	4.83			0.13									0.43
21		3.24			0.10				<del>-</del>					0.42
22		2.82			0.07									0.36
23		2.75			0.07									0.38
24		2.65			0.0									0.38
25		2.55			0.12									0.37
56		2.33			0.13									0.38
27		2.45			0.10									0.37
83		2.83			0.10							. <u> </u>		0.39
53		3.48			0.11									0.40
30		2.85			0.12									0.40
31		3.13			0.11	1								0.39

Page 1 of 2

	Total	0.36	0.41		0.44	0.42	0.41	0.40	0.44	0.42	0.38	0.41	0.40	0.43	0.41	0.44	0.41
	RESTDUAL C																
NATION	Free		-														
POST-CHLORINATION	SO2			-													
P03	MH3			-													
	Dos.	<b>├</b>		1													
	- E		<u> </u>	=	==											==	:==
	Total								! ! !								
	RESTDUAL C																
NATION	Free	0.08		7	0.20	0.18	0.17	0.17	0.19	0.14	0.14	0.18	0.16	0.13	0.12	0.11	0.13
PRE-CHLORINATION	50,			-													
	£																
PRE- & POST-1	2005	4 22		2.00	2.40	2.42	2.97	2.69	2.79	2.56	2.56	2.55	2.28	2.14	2.20	2.69	2.06
PRE- &	12																
	DATE	-	.   .	7	m	4	2	9	7	8	6	9	=	12	13	14	15

	PRE- & POST+		PRE-CHLORINATION	INATION				1	POST-CHLORINATION	INATION		
DATE	1 012	'_	5	RES	RESTOUAL CI	2		1	5	RES	RESTOUAL C	-
	Dem. Dos.	m3	202	Free	Comb.	otal	Dem. Dos.	£	202	Free	Comb.	Total
16	3.03	==		0.13								0.45
17	2.63			0.08				<u> </u> 	<u> </u>			0.42
18	2.96	<u> </u>		0.11		<del></del>	<u>-</u>	<u> </u> 				0.44
19	2.71	<u> </u>		0.12			<u>-</u>	<u> </u> 	<u> </u>			0.43
02	2.12	<u> </u>		0.08				<u> </u> 				0.40
21	2.94	<u> </u>		0.10			<u></u> -	<u> </u>				0.43
22	2.57			0.14		 :		<u> </u> 				0.45
23	3.24			0.12				<u> </u> 	<u> </u>			0.42
24	2.52			0.12								0.42
25	2,30			0.08								0.42
26	2.43			0.13								0.41
27	2.30			0.17								0.44
8	2.49			0.12								0.39
53	2.36			0.13								0.39
30	2.52			0.11								0.40
31						===			<u> </u>			
1			-	-	-	=	_	_	_	_	_	-

	1		1	ABE CUI OBTUATION	MATTAN					204	POST-CHLORINATION	NATION		
DATE	PKE- & PUSI-   []3	- <u>-</u> -		Curon S	RES	RESTDUAL CT	7	C12	7	Ä	S	RE	RESTDUAL CI	
	Dem.   Dos.	=  s	_ ₹	202	Free	Comb.	lotal	Dem.	Dos.	3	2005	Free	Comb.	lotal
-	2	2.50			0.14									0.44
2		2.40	-		0.14									0.44
9	2	2.32			0.16									0.45
4	2	2.03			0.20									0.44
2		1.95			0.18									0.43
9		1.98			0.11									0.39
1		2.20			0.20									0.44
60		2.26			0.21									0.45
6	<u>-</u> -	1.89			0.22									0.42
2		1.47			0.19									0.38
=	2	2.11			0.18									0.39
12	2	2.21			0.18									0.45
13	2	2.11			0.22				-					0.45
14	2	2.02			0.16									0.41
15	2	2.05			0.18			==						0.42
	_	=	-	•										

	000	- 100g		BOF - CHI OD INATION	NOTION					P08	POST-CHLORINATION	NATION		
DATE	C12	2 7031	3	5	RE	RESTDUAL CI	7		28.5	Æ,	50,	RES	RESTDUAL CY	7
	Dem.	Dos.		200	l ree	COMO.	10191	Dem.	nos.	2	,	וננ	0	
16		1.69			0.21									0.45
17		2.14			0.18									0.40
18		1.61			0.18									0.42
19		2.32			0.09									0.40
202		1.92			0.12									0.46
21		2.06			0.14									0.42
22	:	2.20			0.15									0.42
23	:	1.79			0.19									0.45
24		2.51			0.19									0.45
25		2.05			0.22									0.45
26		2.07			0.20									0.42
27		2.13			0.21									0.43
83		2.88			0.18									0.45
62		1.79			0.18			-=-						2.46
98		2.40			0.17			:==						0.45
=		2.11			0.17			<u> </u>	-					0.45

	1 - Jag	1 POST- 1		PRE-CHLORINATION	THATION					PO	POST-CHLORINATION	NATION		
DATE	2				REG	RESTOUAL C	١	ے ا	12	1	5	RE	RESIDUAL C	12
<u>.</u>	OEM.	908	E	202	Free	Comb.	Total	Dem.	Dos.	M3	202	Free	Comp.	Total
-		2.19			0.16			==:						0.44
2		2.48			0.17			<u> </u> 						0.44
<u> </u>		2.29			0.21									0.42
4		2.06			0.20									0.42
2		2.00	<u> </u>		0.21									0.43
و		2.39	<u> </u>		0.21									0.44
		2.22			0.17									0.39
80		2.66		<u> </u>	0.16									0.43
6		2.84	<u> </u>	<u> </u>	0.13									0.46
9		2.12			0.21									0.44
=		2.10	<u> </u>		0.16									0.41
12		2.22	<u> </u> 		0.18									0.49
13		1.86			0.22			<u> </u>						0.46
14		1.86			0.19									0:47
15		1.75			0.22			==						0.45

(mg/L)

	PRE- & POST-		PRE-CHLORINATION	NATION					P0	POST-CHLORINATION	INATION		
DATE	C12	¥	50,	Free	RESIDUAL CI	2019		2	NH <sub>2</sub>	\$0,	<b>Z</b>	RESTOUAL C	7
16				0.27									0 45
17	1.64			0.17	<u> </u>	<del></del>		-					0.42
18	1.97	<u> </u>		0.18									0.45
19	1.90	<u> </u>		0.21				<del>-</del>					0.48
50	1.99			0.22				<del>-</del>					0.47
21	1.39			0.21				<u>-</u>					0.49
22	1.54			0.28				<del>-</del>					0.47
23	2.25			0.28				<u>-</u>					0.50
24	1.71			0.26				<del>-</del>			<u> </u>		0.49
25	2.03			0.22									0.45
26	1.27			0.19									0.43
27	1.20			0.22									0.45
8	1.58			0.19									0.42
59	1.28			0.25									0.46
90	1.39			0.15									0.40
31													
				-		_	_	-	_	_		_	_

## TABLE 3.2: DISINFECTION PROFILE

Page 1 of 2

		130	8	BBE_CHI OBTWATTON	WATTOW					200	POST-CHLORINATION	NATION		
DATE	rke- & rusi-	5		5	RES	RESTOUAL C12		5	C12	Ę	20,	<b>X</b>	RESTOUAL C	7
	Dem. D	-50	E III	275	Free	Comb.	lota	Dem.	.son	7	7	Lie	COMD.	101
		1.23			0.20									0.42
2		1.34			0.20								-	0.42
m	<u></u>	1.57			0.18									0.42
4		1.39			0.23									0.43
		1.52			0.22									0.43
9	2	2.21			0.19									0.46
		1.59			0.22									0.49
60		1.21			0.16									0.48
6		1.77			0.18									0.42
9	1	1.38			0.22							-		0.46
=	1	1.64			0.20									0.42
12	1	1.50			0.24							_		0.43
13	1	1.54			0.19							_		0.41
14	1	1.40			0.22									0.43
15		1.49			0.18									0.41



TABLE 4.0: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION SUMMARY (mg/L)

			1006			1985			1984			1983	
		HIN.	HAX.	AVG.	HIN.	MAX.	AVG.	HIN.	MAX.	AVG.	HIN.	MAX.	AVG.
NAC	PAC (1) KMn04 L1me Soda Ash F Dos.	0.33	66.0	0.76	0	0	0	0	0	0			
	PAC KMn04 Lime Soda Ash F Dos.	0	0	0	0	0	0	1.23	1.23	1.23			
MAR	PAC KMn04 Lime Soda Ash F Dos.	0.29	0.72	0.46	1.36	1.36	1.36	0	0	0			
APR	PAC KMn04 L1me Soda Ash F Dos.	0	0	0	0.83	1.08	0.97	1.11	1.11	1.11			
¥	PAC KMn04 Lime Soda Ash F Dos.	0.40	1.05	0.66	0.50	1.09	0.85	0	0	0			
NOC	PAC KMnD4 Lime Soda Ash F Dos.	0.92	0.92	0.92	0.50	0.66	0.58	0	0	0			

<sup>(1)</sup> Powdered Activated Carbon

TABLE 4.0 (cont'd.) (mg/L)

			1986			1985			1984		L	1983	
		HIN.	HAX.	AVG.	HIN.	MAX.	AVG.	MIN.	MAX.	AVG.	MIN.	MAX.	AVG.
JA,	PAC (1) KMn04 Lime Soda Ash F Dos.		1.15	0.80	89.0	69.0	89.0	.53	66.	0.76			
AUG	PAC KMn04 Lime Soda Ash F Dos.	0.38	1.89	0.87	0.40	1.59	0.68	0.67	1.94	1.18			
SEP	PAC KMn04 Lime Soda Ash F Dos.	0.38	1.04	0.64	0.55	1.25	68.0	0	0	0			
100	PAC KMn04 Lime Soda Ash F Dos. F Res.	0	0	0	0	0	0	0	0	0			
<u> </u>	PAC KMn04 Lime Soda Ash F Dos.	0	0	0	0.51	1.23	0.77	С	0	0			
230	PAC KMn04 Lime Soda Ash F Dos.	0	0	0	0	0	0	99.0	1.97	1.41			

Page 1 of 2 TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE
JANUARY 1986

DATE	PAC' 1 KMn04	LIME	ASH	NaHCO <sub>3</sub>	Dosage	reconing
Γ						
~						
4						
						1 1 1 1 1 1 1
9						
6	 					
_ _ _						
12	 					
E 2	 					
14						
15	 					

(1) Powdered Activated Carbon

TABLE 4.1 (cont'd.) JANUARY 1986 (mg/L)

FLUORIDE ige   Residual																
PLU																
NaHCO <sub>3</sub>																
S0DA ASH																
LIME																
KMn04																
PAC				0.33	0.81	0.67	0.99	0.83	06.0							
DATE	16	17	81	i	2	. ~ !	22	23	24	25	92	22	88	٤	20	31

Page 1 of 2 (mg/L) TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE MARCH 1986

				SODA	31	FLUC	FLUORIDE
DATE	PAC	Man04	I I	ASH	Nancu3	Dosage	Residual
_							
2			_			1	
m							
4							
5							
9						1	
1							
8						) ) ) ) )	
6						- 1	
2							
=					1		
12							
13	0.35						
4	0.43			!	-		
15	0.53						
					_		

DATE	PAC	KMn0 <sub>4</sub>	LIME	SODA ASH	NaHCO <sub>3</sub>	FLUORIDE Dosage   Residual	E s1dual
16	0.45						
17	0.41						
18	0.51						
1	0.50						
2	0.44						
21	0.29						
22	0.72						1
23							
24							
25							
56							
27							
88							
- 62							
e						<del>!</del>	
31							
-							

16 17 18 19 20 1.05 21 22 0.52 23 0.40					
<u> </u>		<del></del>			
23 22 23 23 23 23 23 23 23 23 23 23 23 2					
23 23 23 23 23 23 23 23 23 23 23 23 23 2	0 12 12				
2 2 2 2	0 2   2				
22	0   2				
23	0 2				
<del>!</del>	_				
	_	-	1000000		
24					
26					
27				1	1
53	 !			1	
30					-
31					



Page 1 of 2 (mg/L) JULY 1986 TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE JULY 19

_		
DDOTOCO	2000	
Noon	2	
Z	2	

3	1
٦,	ı
_	1
₹	ı
€	ı
ಶ	

Γ.	1			SODA	OJHAN	FLUO	FLUORIDE
DATE	PAC	KMn04	LIME	ASH	Nancu3	Dosage	Residual
Г							
<del>-</del>							1
<del>-</del>							
:							
2							
	1.03						
12	0.91						
13	0.64						
14	0.95						
15	1.08						
_							

DATE	PAC	KMn04	LIME	ASH	NaHCO <sub>3</sub>	Dosage	r Luukiut ige   Residual
16	0.70						
17	0.71						
18	1.15						
19	96.0		_				
20	0.65		_				
21	1.03						
22	0.76						
2	1.14						
1	0.67						
25	0.70		_				
92	0.37		_				
27	0.74						
28	0.40						
	0.39						
90	98.0						
31	86.0					_	

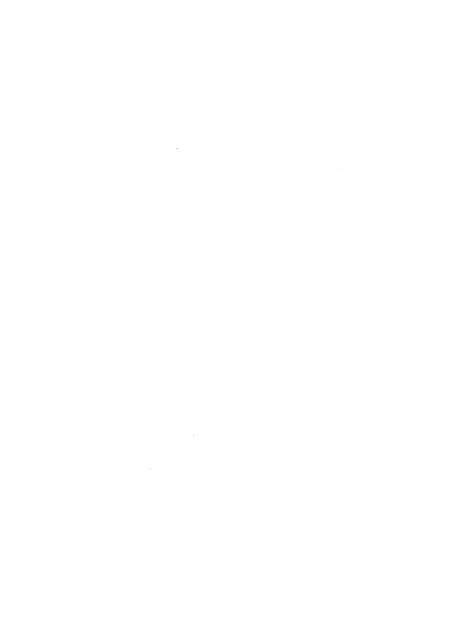
Page 1 of 2 (mg/L) AUGUST 1986 TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE AUGUS

DATE	PAC	KMn0 <sub>4</sub>	LIME	SODA	NaHCO <sub>3</sub>	FLUORIDE Dosage   Residual	- Pand
						۰ــا	
-	86.0						
2	1.0						
3	0.88						
4	0.49				1		
2	0.75						
9	1.89						
7	1.33			1			
8	06.0						
6	0.81						
01	0.84						
11	1.28						
12	0.93						
<b></b> 1	1.12					-	
14	0.78						
15	29.0						

16 1.12 17 1.07 18 0.75 20 0.70 21 0.61 22 0.65 23 0.38 24 0.99 25 0.70			
22 23 23 24 25 25 25 25 25 25 25 25 25 25 25 25 25			
22 22 23 23 24 24 25 25 25 25 26 26			
23 24 24 25 25 25 25 26 26			
23 24 25 25 26 26 26		_	
25 26 26			
:			
28   0.83		 	
29 0.77			
		<u> </u>	
31			

Y ADJ. & Page 1 of 2 SEPTIMBER 1986 (mg/L) TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE SEPTIME

	1			SODA	0011-11	FLUC	FLUORIDE
DATE	PAC	Munu4	LIME	ASH	nancu3	Dosage	Residual
-	0 83						
-	3			-		-	
2	0.40		_				1
m	0.47						
4	1.04						
5	0.38		. ;				
9	0.51			1			
7	77.0						1
80	0.68		_				1
6	0.47						
10	0.93						
=	0.91						
12	0.62						
13	0.89						
14							
15			_				



PAC	KMn0 <sub>4</sub>	LIME	SODA	NaHCO <sub>3</sub>	Dosage	FLUORIDE ge Residual
1						
1						
				1		
					1	
1.36						
	_					



TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE APRIL 199

APRIL 1985

Page 1 of 2 (mg/L)

MOE WPOS PROTOCOL	LIME   SODA   NaHCO3   FLUORIDE   ASH   NaHCO3   Dosage   Residual														
MOE WPOS PROTOCO	I SODA I I ASH I														
	PACK	0.83	0.99	76.0	66.0	1.08									<u>-</u>
	DATE	-	2	m	4	2	٠	^	6	2	=	12	13	7	15



16 18 19 20 20 21 22 23 24 25 26 27 28 29 29 20 20 21 22 23 24 25 26 27 28 29 29 20 20 21 22 23 24 25 26 27 28 29 29 20 20 20 20 20 20 20 20 20 20	DATE	PAC	KMn04	LIME	ASH ASH	NaHCO <sub>3</sub>	Dosage   Residual
	16						
	12						
	138	0.50					-
<del>'</del>	13	1.09					-
<del></del>	2	0.95					-
23 24 25 26 27 29 29 30	21						. —
23 24 25 26 27 28 29 30	22						-
24 25 26 27 28 29 30	23						
25 26 27 28 29 30	24						
26 27 28 29 30	52						
28 29 30 31	56						
28 29 30	27						
30	88						
31	82						
31	8					-	
	33						



DATE	PAC	KMn04	LIME	ASH	NaHCO <sub>3</sub>	Dosage   Res	Residual
16							
12							
81	0.65						
19	0.53						
8							
21						1	
22							
							3
25							
56							
27	0.50					1	
28	99.0			1			
53						1	
30							
31		_				_	





Page 1 of 2 (mg/L) TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE AUGUST 1985

## MOE WPOS PROTOCOL

DATE	PAC	KMn0,	LIME	NOUA PCH	NaHCO <sub>2</sub>	Docade   Res	Res Idual
		7			,	╌	
-	0.69				1		
2	09.0						
3	09.0				1	<u> </u>	
4	0.50				1		
5	0.65			,			
9	0.57					·	
7	0.77					<del> </del>	
1 00	0.82						
6	0.51						
	0.55						
=	0.51						
12	0.61						
13	0.29					-	
	0.72						
15	0.84						

0.98 0.98 0.97 0.93 0.60 0.60 0.60 0.60 0.60	DATE	PAC	KMnD	TIME	SODA	NaHCO,	FLUORIDE	RIDE
0.98 0.97 0.97 0.61 0.61 0.63 0.60 0.60	1	2	7		ASH	2	nosage	res lang i
0.97 0.93 0.61 0.80 0.51 0.63 0.60 0.60	16	86.0				1		
0.93 0.61 0.80 0.51 0.60 0.60 0.60	į i	1.07				1		,
0.54 0.63 0.60 0.60 0.60 0.60 0.60	18	0.38						
0.51 0.54 0.63 0.60 0.60 0.60	19	0.97						
0.61 0.80 0.54 0.60 0.60 0.60 0.60	20	0.93						
0.54 0.63 0.60 0.60 0.60 1.59	21	0.61						
0.51 0.63 0.60 0.60 0.60 0.63		0.80			- 1			
0.60 0.60 0.60 0.60 1.59	23	0.51						
0.60 0.60 0.63 1.59	24	0.54						
0.40 0.60 0.63 1.59	52	0.63						
0.60	56	0.40						1
0.60	27	09.0						
1.59	82	09.0						
	53	0.63						
31	8	1.59						
	31							

Page 1 of 2 (mg/L) TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE SEPTEMBER 1985

MOE WPOS PROTOCOL

FLUORIDE Dosage   Residual			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1						1	1	 
NaHCO3													
SODA ASH									1				
LIME													
KMn0 <sub>4</sub>													
PAC								1.03	0.55	1.25	0.74		
DATE	 2	m	4	2	9	7	. 8	6	9		12	13	15



Page 1 of 2 (mg/L) TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE NOVEMBER 1985

MOE WPOS PROTOCOL

	4				200		
DATE	PAC	KMnU4	LIBE LIBE	ASH	nancu3	Dosage	Residual
-							
-					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
2						_	
8							
14							
2							
9							
7	0.74						
8	1.23			! ! ! !			
6	0.65						
2	0.68				1		
	0.95						
12	1.08						
13	0.72						
14	0.56						
15	0.92						

_	

DATE PAC 16 17 18 0.51 19 0.89 20 0.75 21 0.75	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	KMn04	ž I	ASH	NaHCU <sub>3</sub>	Dosage	ge Residual
10 10 10 10 10 10 10 10 10 10 10 10 10 1	12 8 6 2						
17 19 19 20 20 21 21 21 21 21 21 21 21 21 21 21 21 21	2 6 6 5					_	
118	23 89 87 57						
20	68 89 87 57						
20	6 5						
21	75						
	-				1		
	89				1		
2	4						
24 0.60	00						
25							
26							
27							
28							
29							
30						; ;	
31							

DATE	PAC	KMn04	LIME	ASH	NaHCO <sub>3</sub>	Dosage	FLUORIDE ge Residual
16							
17	1.23						
18	1.23						
19	1.23						1
202							
21							
22							
23							
24				1			
25							
56				1 1 1 1 1 1 1 1			
22	 :						
62							
90							
31							

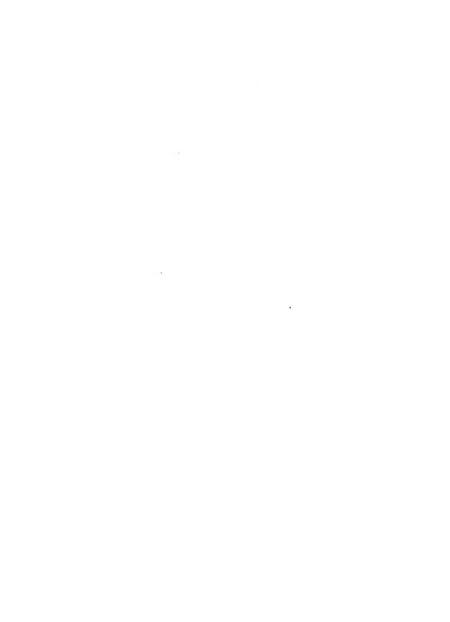


TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE APRIL 19

Page 1 of 2 (mg/L) APRIL 1984 MOE WPOS PROTOCOL

		,		SODA	511.51	FLUC	FLUORIDE
DATE	PAC	KMnU4	LIME	ASH	Namuu3	Dosage	Residual
_							
						1	
,					-		
m							
4				1			
2							6 6 6 8 8 8 8 8
9							
8				; ; ; ;			
6							
2							
=							
12	1.11						
13							1
14							1
15							
		_			_		



TABLE	FABLE 4.1 (cont'd.)	, G	JULY 1984	=	(mg/L)		Page 2 of 2
				SODA		FLUG	FLUORIDE
DATE	PAC	KMn04	LIME	ASH	NaHCU3	Dosage	Residual
16							
17							
18							
19							
20							
21					1	1	
22							
23						1	
24					1	1	
25							
92							
27							
28							
62					1		
30	0.53						
33	0.99						



Page 1 of 2 (mg/L) TABLE 4.1: T&O CONTROL, ALKALINITY ADJ. & FLUORIDATION PROFILE AUGUST 1

RIDATION PROFILE AUGUST 1984

MOE WPOS PROTOCOL

			1	SODA	0011-11	FLU	0
DATE	PAC	KMnU4	LIME	ASH	naurn3	Dosage	Residual
-	0.67						
2	1.10						
3	1.06						
4	1.17					1 1	
S	1.92						
9	96.0						
,	0.80						
80	1.02						
6	1.12						
2	1.22						
=	1.20						
12	1.83						
13	1.67						
7	1.51						
15	0.97						

DATE	PAC	KMn04	LIME	ASH	NaHCO <sub>3</sub>	Dosage   Res	Residual
16	1.30						
17	0.87						
18	0.92						
19	0.97						
20	1.32						
21	1.94		1				,
22	1.18						
23	1.17						
24	1.17						
25	1.00						
56	0.88						
27	0.97						
28							
53							
30							
31							

FLUORIDE age Residual																
Dos			<del> </del>										. <u> </u>			
SODA NAHCO3																
LIME   SO					-											
KMn04																
PAC							1.09	1.65	0.68	1.28	1.97	1.81				
DATE	16	17	18	19	20	21	22	23	24	52	92	27	82	53	æ	3



## TABLE 5 WATER PLANT OPTIMIZATION STUDY

"WATER QUALITY SUMMARY"



DRINKING WATER 08J/ GUIDELINE<sup>1</sup> 250 mg/L 25 DETECTION LIMIT 0.01 UMH0/CM 0.2 mg/L 0.05 mg/L 0.1 Eg/L 0.2 5.5 0.1 19/L 0.1 mg/L 0.1 19/L 30.5 26.5 28.0 29.5 101 95.8 337 DEC 6.0 374 102 96 ě 24.0 2.5 96 326 100 23.5 2.5 95 SEPT 313 25.5 3.0 313 AUG 93 27.5 27.0 2 30.0 30.5 2 2.0 JULY 99 333 98 3.5 JUNE 93 334 1 9 16.0 30.6 1.7 103 361 ¥ 25.7 27.6 1.5 329 AP. 99 30.8 5.0 66 ¥ 354 24.6 42.0 24.8 35.6 26.5 £8 101 96 397 45.0 101 97 JAH 325 GENERAL CHEMISTRY FIELD CHLORINE (COMBINED) FIELD CHLORINE (TOTAL) FIELD CHLORINE (FREE) TOTAL 76 1/6 GENERAL CHEMISTRY 76 76 ş CONDUCTIVITY ALKAL INITY AMMON I UM FIELD PH CALCIUM CHLORIDE COLDUR

TABLE 5.0: (cont'd.)

ORINKING	LIMIT* GUIDELINE		1 570	2.4		v	10 mg/l 88 N	1 mg/L 85 N	0.15 #9/L *		
DWSP	LIMIT			0.01 #9/L	0.5 m9/L	0.05 m9/L	0.05 #9/L	0.005	0.1 m9/L		0.01 #9/L
	DEC				135					8.2	
	NO.				148 137					8.3	
	100				130		_			8.3	
	SEPT				128	-				8.3	
	AUG				126 130		-			8.3	
986	JULY				134 135				•	8.2	
1.9 86	JUME				139		_			8.2	
	МАУ				140					8.3	
	APR				133		-			8.4	
	MAR				138					8.2	
	168				142					8.1	
	JAN				136 136					8.1	•
	GENERAL CHEMISTRY (Cont.d)	FIELD TEMPERATURE R	FIELD TURBIDITY R	FLUORIDE , R	HARDNESS mg/L T	MAGNES I UM mg/L T	MITRATE mg/L T	NITRITE mg/L T	NITROGEN TOTAL RJELDAHL R =9/L	α <b>-</b>	PHOSPHORUS FILTERED REACTIVE R 11

۲, ۲۰)	DNI	JAM FEB MAR APR MAY JUNE JULY AUG SEPT OCT MOV OEG	R 89/L	T 0.1	T 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	R   14.1   18.8   12.0   13.1   4.75   2.25   3.16   4.39   4.37   5.58   8.83   23.3   0.01   0.26   0.18   0.21   0.53   0.30   0.15   0.15   0.11   0.10   0.14   0.14   0.55   0.01		T 89.1.	R 0.001	R 0.001	0.001 T	0.02 T	
		MAR				18.8 12.0 0.18 0.21							_
~		JAN				14.1							
TABLE 5.0: (cont'd.)		GENERAL CHEMISTRY (CONT. d)	PHOSPHORUS TOTAL R	SODIUM #9/L T	TOTAL SOLIDS R m9/L T	R NTO NTO	HETALS	ALUMINUM B9/L T	ARSENIC B9/L T	BARIUM B9/L T	BERYLLIUM B9/L T	BORON B9/L T	

TABLE 5.0: (cont'd.)

							9 6 1	986						DWSP	OR I NK I NG
	METALS (Cont'd)	NAU	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SFPT	100	NOV	DEC	DETECTION WATER OBJ/ LIMIT* GUIDELINE <sup>1</sup>	WATER OBJ/ GUIDELINE
CHROMIUM	R 19/L													0.001 mg/L	0.05 mg/L
COBALT	R mg/L T													0.001 #9/L	
COPPER	R mg/L T												-	0.001	1/6=
CYANIDE	R mg/L T								_					0.001	0.2 mg/L
IRON	R B9/L T		0.6100.058 0.0060.005	0.6100.058 0.0060.005 0.005	9002	500°0		0.032n.036 0.019 0.0050.025 0.005	0.036	0.019		0.1301.400	1.400	0.002 mg/L	0.3 mg/L c
LEAD	■9/L R													0.003 mg/L	0.05
MANGANESE	R mg/L T							•						0.001 m9/L	0.05 mg/L
MOLYBDENUM	R mg/L 1								-					0.001 mg/L	
MERCURY	R 19/L													0.01 u9/L	1 Mg/L
NICKEL	R mg/L T								·····	_		•		0.002 =9/L	

							1 9 8	86						DWSP	ORINKING
MASS SPEC. (Cont'd)		JAN	FEB	MAR	APR	HAY	JUNE	JULY	AUG	SEPT	100	NON.	DEC	DETECTION LIMIT*	DETECTION WATER OBJ/ LIMIT* GUIDELINE <sup>1</sup>
TE TRACHLORBUTANE Ug/L	<b>α</b> ⊢													0.1 ug/L	
TETRACHLOROBIPHENYL ug/L	α <b>-</b>													0.1 ug/L	
BACTERIA						,	-								
RAW WATER:															
TOTAL COLIFORM MF count/100mL	œ	302	302 1056	213	118	2583	56	33	24	20	609	263	1169		
TOTAL COLIFORM BKGD COUNT/100mL	~		1388 2183	647	18730	48730 18010 4935		9415	9415 56475 2266	2266	1460	1460 2603 5994	5994		
FECAL COLIFORM MF count/100mL	œ	9	9	7	ю	84	7	12	10	7	7	2	27	•	0/0.1
STANDARD PLATE COUNT MF COUNT/100mL	œ													•	200
TREATED WATER:															
PRESENT/ABSENT TEST (1)	A T P T							4	4	1	4	8	4		
TOTAL COLIFORM BACKGROUND MF count/100mL	-	-	0	0	0	800	0	0				-	0	0	0wD0 Bacti
TOTAL COLIFORM MF COUNT/100 ML	-	0	0	0	0	0	0	0					0		

(1) Number of tests done per month.

TABLE 5.0: (cont'd.)

						1 9	98						OWSP	DRINKING
BACTERIA (Cont'd)	JAN	FEB	MAR	APR	HAY	JUNE	JULY	AUG	SEPT	100	NOV.	DEC	LINIT*	LINIT* GUIDELINE
IREATED WATER: (Cont'd)														
FECAL COLIFORM MF	_						0		0			0	0	0000
count/100mL														Bacti
STANDARO PLATE COUNT MF COUNT/IML	9	4	7	4	380	009								
IF PRESENT/ABSENT TEST POSITIVE:										_				
Total Coliform 1-100/100mL									-		0			
FECAL COLIFORM P/A 1-10/100mL											0			
E. COLI 1-10/100mL									0					
AROHONAS P/A														
STAPH, AUREUS P/A														
TOTAL COLLIFORM BACKGROUND  COUNT/100mL				-	_				96					

						198	85						DWSP	DWSP DRINKING
GENERAL CHEMISIRY	JAN	FEB	MAR	APR	ΑΑ	JUNE	JULY	AUG	SEPT	100	MOV	DEC	LIMIT	CUIDELINE
GENERAL CHEMISTRY														
ALKALINITY #9/L	102.	102.0 100.0 105.0 144.4 98.6 97.2 96.8 96.4 84.4 82.0 73.4 90.0 88.0 90.0 90.0	105.0 82.0	73.0	98.6	97.2 88.0	96.8	96.4	92.2		97.6 94.2 82.0 81.0	94.2	0.2 #9/L	
AMMONIUM TOTAL mg/L	r 5.02	0.027 0.015 0.112 0.035 0.0410.059 0.110 0.069 0.0360.0360.019 0.010	0.112	0.035	0.041	0.059	.110	690.0	0.036	.036	010.	0.010	0.05 mg/L	
CALCIUM mg/L	α <b>-</b>				_								0.1 #9/L	
CHLORIDE mg/L	R 27.6	27.68 29.95 31.12 27.73 27.48 27.10 25.88 25.11 22.11 25.57 23.49 25.75 27.00 28.00 28.00 28.00 28.00	31.12	27.73 27.00	27.48	27.10	25.88	25.17	28.00	25.57	23.49	25.79	0.2 mg/L	250 m9/L
COLOUR ACU	R 22.0		4.5 16.5 31.0 0.5 1.0 1.5	31.0	3.5	2.5	3.0	1.5	3.5		8.0	14.5	0.5 TCU	5 1CU
CONDUCTIVITY umho/cm	R 346	345 346	354 377	341 353	339 346	336 335	330 328	326 332	324	337	323	333	0.01 UMH0/CM	
FIELD CHLORINE (COMBINED)	<b>α</b> ⊢												0.1 #9/L	
FIELD CHLORINE (FREE) =9/L	α <b>-</b>									-		-	0.1 mg/L	
FIELD CHLORINE (TOTAL) mg/L	<b>∝</b> ⊢												0.1 mg/L	
на стат	« <b>-</b>												0.2	

TABLE 5.0: (cont'd.)

						1.9	82					_	dSMQ	DRINKING
GENERAL CHEMISTRY (Cont'd)	JAN	FEB	HAR	APR	МАУ	JUNE	JULY	AUG	SEPT	100	NON.	DEC	LIMITA	LIMIT* GUIDELINE
FIELD TEMPERATURE *C	α ⊢													
FIELD TURBIDITY FTU	<b>α</b> ⊢													1 570
FLUORIDE . mg/L	<b>∝</b> ⊢												0.01 #9/L	2.4 mg/L
HARDNESS m9/L	n 139.4	139.4135.0139.0137.3132.0127.0123.0127.0130.0 136.0139.0133.0133.0129.0126.0128.0130.0	139.0	137.3	132.0 133.01	29.0	23.01 26.01	27.0	130.0		130.0 136.0	130.0130.0 136.0136.0	0.5 #9/L	
MAGNESIUM B9/L	<b>∝</b> ⊢												0.05	U
NITRATE #9/L	« <b>-</b>												0.05 mg/t	10 mg/L es N
NITRITE #9/L	n .0110	.0110.0076.0218 .0227,0055 .0100 .0084 .0094 .0105 .0086 .0132 .0062	.0218	.0227	90055	0010	0084	0094	.0105	9800	.0132	.0062	0.005 mg/L	1 mg/L 88 N
NITROGEN TOTAL KJELDAHL mg/L	R 0.308	0.3080.2520.5320.4400.3100.3200.3600.3180.3360.236	0.532	0.440	0.310	320 0	360	,318	0.336	0.275	0.435	0.228	0.1 mg/L	0.15
£	R 8.11		7.50 7.40 7.91 8.45 7.50 7.40 7.40 7.80	7.91		8.34 8.60 8.35 8.20 7.80 7.90 7.80 7.50	8.60 7.90	8.35	8.20		8.04 7.30	8.20		
PHOSPHORUS FILTERED REACTIVE	.0136	.0136 .010d .0264 w338 .0015 .0021 .0060 .0084 0033 10038 .0233 .0069	.0264	0338	.0015	.0021	.0060	0084	0033	96003	.0239	6900.	0.01 =9/L	

							6 -	85						DWSP	DRINKING
GENERAL CHEMISTRY (Cont'd)	RY (Cont'd)	JAN	FEB	MAR	APR	Α¥	JUNE	אחר	AUG	SEPT	100	NO.	DEC	LIMIT	LIMIT* GUIDELINE
PHOSPHORUS TOTAL mg/L	A 1													0.01 mg/L	
SODIUM mg/L	₩ ⊢													0.1 mg/L	
1/6m 101al solids	æ <b>⊢</b>													1 #9/L	
TURBIDITY	<b>&amp;</b> F	22.7	18.8 0.36	33.9	23.9	2.3	T 0.27 18.8 33.9 23.9 2.3 1.69 T 0.27 0.36 0.40 0.15 0.13 0.13	1.78	6.21	1.78 6.21 5.97 4.35 0.14 0.17 0.12 0.10	0.10	35.8 8.1 0.18 0.12	8.1 0.12	0.01 FTU	FTU
METALS															
ALUMINUM B9/L	æ F													0.003 #9/L	
ARSENIC mg/L	<b>∝</b> ⊢													0.001 #9/L	0.05 #9/L
BAR1UM B9/L	œ F													0.001 #9/L	1/6
BERYLLIUM mg/L	« <b>-</b>													0.001 #9/L	
BORON mg/L	<u>«</u> –													0.02 mg/L	5 =9/L
CADM TUM mg/L	æ F													0.0003 mg/L	0.005 mg/L

							6 1	85						dSMO	DRINKING
Ĭ	METALS (Cont.d)	JAN	FEB	HAR	APR	ΗΑΥ	JUNE	JULY	AUG	SEPT	100	MOV	DEC	DETECTION LIMIT*	LIMIT* GUIDELINE
CHROMIUM	R T													0.001 mg/L	0.05 mg/L
•	R 1													0.001 mg/L	
•	R 1													0.001 mg/L	1 =9/L
CYANIDE	R #9/L T													0.001 mg/L	0.2 mg/L
í	R #9/L 1	3.10	3.10 0.18 18.50 0.01 0.01	18.50	9.70	9.70 0.03 0.04 0.04 0.01 0.01		0.026 0.019 0.050 0.01 0.01 0.01	.019	0.050		0.03	0.03 0.02	0.002 mg/L	0.3 mg/L c
Ĭ.	mg ∕L R													0.003 mg/L	0.05 m9/L
MANGANESE	R M9/L T									·				0.001 #9/L	0.05
MOLYBDE NUM	R mg/L T													0.001 #9/L	
MERCURY	R 109/L I								,					0.01 ug/L	1/60
Ĭ,	R B9/L T													0.002 mg/l	

							1 9	82						DWSP	DRINKING
MASS SPEG. (Cont'd)		JAN	81	HAR	APR	HAY	JUNE	JULY	AUG	SEPT	100	NON.	DEC	E IMIT*	EIMIT* CUIDELINE
TETRACHLORBUTANE .	« <b>-</b>													0.1 ug/L	
TETRACHLOROBIPHENYL ug/l	<b>«</b> –											•		0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF COUNT/100mL	œ	358	573	454	734	6	2	80	92	9	313	3229	323		
TOTAL COLIFORM BKGD COUNT/100mL	œ	3250	2330	3025	3070	267	2451	08008	29600	80080 59600 49500 14720 32825 1953	14720	32825	1953		
FECAL COLIFORM MF COUNT/100mL	œ	33	31	33	142	2	2	2	14	7	12	92	7	•	0/0.1
STANDARD PLATE COUNT MF COUNT/100mL	œ													•	200
TREATED WATER:															
PRESENT/ABSENT TEST	۲ <u>۲</u>								•						
TOTAL COLIFORM BACKGROUND MF COUNT/100mL	-	0	0	0	0	0	0	321	0	0	0	п	0	0	OWDO Bacti
TOTAL COLIFORM MF count/100mL	-	0	0	0	0	0	0	0	0	0	0	0	1		

TABLE 5.0: (cont'd.)

BACIERIA (Cont'd)   JAH	83 4	HAR	APR H	HAY	JUNE	JULY	AUG	1035	1	NUM.	2,0	DETECTION WATER 08J/	71 00 02 743
T T T T T T T T T T T T T T T T T T T							i	120	3	2	230	LIMIT	LIMIT* GUIDELINE
I I JAITISE													
POSITIVE:											0	0	ODWO Bact!
F PRESENT/ABSENT TEST POSITIVE:		8		7	4	482	9	9	99	2	2		
Total Collform													
1-4/100 mL													
FECAL COLIFORM P/A	 												
E. COLI P/A T	 	<del></del>											
AROMONAS P/A													
STAPH. AUREUS P/A T													_
TOTAL COLIFORM BACKGROUND T COUNT/100mL	 	<del></del>											
-	 												

PLANT GRIMSBY TABLE 5.0:

WATER QUALITY - 1-YEAR SUBMARY

	_					1984	4						DWSP	ORINKING
GENERAL CHEMISTRY	JAN	168	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	DCT	VON	DEC	LIMIT*	LIMIT* CUIDELINE
GENERAL CHEMISTRY														
ALKALINITY =9/L	97	93	100 86	100	97	97 88	94	90	99	93	96	97 85	0.2 mg/L	
AMMONIUM TOTAL mg/L	п 0.00	80.111	0.0080.111 0.047 0.032 0.046 0.064 0.062 0.056 0.048 0.0340.015 0.025	0.032	0.046	0.064	0.062	950*(	0.048	0.034	0.015	0.025	0.05	
CALCIUM #9/L	<b>α</b> ►												0.1 mg/L	
CHLORIDE =9/L	R 27.9	228.44 028.00	27.9428.44 29.41 27.42 27.73 27.51 25.40 23.73 24.72 24.61 25.02 25.05 25.05 25.05 25.05 25.00 28.00 27.00 28.00 27.00 28.00 27.00 28.00	27.42	27.73	27.51	25.40	23.73	24.72	24.61 26.00	25.02	25.53	0.2 mg/L	250 #9/L
COLOUR ACU	R 2.2	9.7	8.0 1.0	12.5 9.0 0.5 0.5	9.0	3.0	1.0	3.5	7.0 3.5	3.5	0.5	1:5	0.5 TCU	5 TCU
COMDUCTIVITY umho/cm	R 339	326	351 376	341 353	341	324 334	329	322 326	322	320 317	328	331	0.01 UNH0/CH	
FIELD CHLORINE (COMBINED) =9/L	æ <b>⊢</b>												0.1 mg/L	
FIELD CHLORINE (FREE) mg/l	<b>α</b> ⊢									_			0.1 mg/L	
FIELD CHLORINE (TDTAL) =9/L	α <b>-</b>												0.1 mg/L	
FIELD PH	α F												0.2	

TABLE 5.0: (cont'd.)

							6 6	84						DWSP	DRINKING
GENERAL CHEMISTRY (Cont'd)	JAN	$\vdash$	811	MAR	APR	МАУ	JUNE	) Jul	AUG	SEPT	100	NOV	DEC	DETECTION LIMIT*	DETECTION WATER OBJ/ LIMIT* GUIDELINE <sup>1</sup>
FIELD TEMPERATURE R	α -														
FIELD TURBIDITY R	α -														1 110
FLUORIDE mg/L T	α -			_										0.01 mg/L	2.4 mg/L
HARDNESS mg/l T	R 138		128 127	142 142	147	133 135	129 135	132	135	125 132	121 125	130 129	127 126	0.5 mg/L	
MAGNESIUM mg/L T	<b>α</b> ⊢													0.05 m9/L	v
NITRATE #9/L T	0	3870.	538(	0.3870.5380.4620.4780.414	0.478	0.414								0.05 mg/L	10 mg/L 85 N
NITRITE #9/L T	90.	948	310	0900	.0152	.0075	.0048,0310,0060 ,0152 ,0075,0109 ,0061,0108 ,0110 ,0055 ,0042,0028	.0061	.0108	.0110	0055	.0042	.0028	0.005 m9/L	1 mg/L
HITROGEN TOTAL KJELDAHL R mg/l	0	.27	.75	0.32	0.34	0.27 0.75 0.32 0.34 0.34 0.32		0.32	0.37	0.32 0.37 0.35 0.28 0.24	0.28	0.24	0.23	0.1 mg/L	0.15
Hd.	∞ œ	8.4	8.2	8.4	8.2	8.3	8.5	8.5	8.5	8.2 7.5	8.2	8.2	8.1		
PHOSPHORUS FILTERED REACTIVE  #9/L	ŏ.	)37 <u>,</u> c	041	0500	0156	.0019	.0037.0041,0050 (0156 .0019.0049 .0034,0080 .0089 .0038,0048 .0042	.0034	.0080	6800.		0048	.0042	0.01 mg/L	
	_														

						1.9	84						DWSP	DRINKING
GENERAL CHEMISTRY (CONT. d)	NAC	£3.	¥	APR	HAY	JUNE	אחה	AUG	SEPT	100	AON	DEC	LIMIT* GUIDELINE	GUIDELINE
PHOSPHORUS TOTAL R	<b>∝</b> ⊢												0.01 mg/L	
SODIUM mg/L	« <b>-</b>												0.1 #9/L	
TOTAL SOLIDS R													1 mg/L	
TURBIDITY NTU	R 5.52 T 0.22		3 0.39	29.8	12.7	20.6 22.7 29.8 12.7 5.9 2.0 5.8 0.28 0.39 0.33 0.18 0.19 0.22 0.16	2.0	5.8	9.1 0.13	5.79	6.60	6.60 20.1 0.12 0.25	0.01 FTU	FTU
METALS														
ALUMINUM B9/L T													0.003 mg/L	
ARSENIC 89/L T													0.001 mg/L	0.05 mg/L
BARIUM mg/L T													0.001 mg/L	1 mg/L
BERYLLIUM B9/L T													0.001 mg/L	
BORON R9/L T	<u>.</u>												0.02 mg/L	5 <b></b> 9/L
CADMIUM B9/L T								-					0.0003 mg/L	0.005 #9/L

TABLE 5.0: (cont'd.)

HETALS (Cont'd)						19 8	84						DWSP	DWSP DRINKING DETECTION WATER 0BJ/
٦	JAN	FEB	HAR	APR	нау	JUNE	JULY	AUG	SEPT	100	NOV.	OEC	LIMIT	GUIDEL INE
													0.001 mg/L	0.05
													0.001 mg/L	
													0.001 =9/L	1/6#
													0.001 mg/L	0.2 mg/L
0.00		0.05 0.16	0.61	0.61 0.56 0.37 0.08 0.02 0.05 0.02	0.37 6	80.0	0.09 0.05	90.0	1.64	0.26	0.26 0.14 0.45 0.01 0.01 0.01	0.45	0.002 mg/L	0.3 =9/L c
								-					0.003 mg/L	0.05 -9/1
													0.001 mg/L	0.05 #9/L
													0.001 =9/L	
													0.01 ug/L	1/6n
œ =-												,	0.002 =9/L	

TABLE 5.0: (cont'd.)

							6-	84						DWSP	DRINKING
MASS SPEG. (Gont'd)		JAN	FEB	HAR	APR	МАУ	JUNE	JULY	AUG	SEPT	100	NO.	DEC	LIMIT	LIMIT* GUIDELINE
TETRACHLORBUTANE ug/L	~ ⊢													0.1 ug/L	
TETRACHLOROBIPHENYL U9/L	œ <b>⊢</b>													0.1 ug/L	
BACTERIA															
RAW WATER:															
TOTAL COLIFORM MF count/100mL	α	27	2220	348	72	188	8800	44	490	74	22	452	239		
TOTAL COLIFORM BKGD COUNT/100mL	œ	136	21030 2907	2907	215	13280	132801253807720 11500097650 3880 2615 1393	7720	15000	97650	3880	2615	1393		
FECAL COLIFORN WF COUNT/100mL	æ	7	1507	28	9	21	45	2	75	6	4	32	15	•	0/0.1
STANDARD PLATE COUNT MF COUNT/100mL	œ	0												•	200
TREATED WATER:															
PRESENT/ABSEMT TEST	PT														
TOTAL COLIFORM BACKGROUND MF COUNT/100mL	-	0				7	45000	н	0	н	0	0	0	•	OWDO Bacti
TOTAL COLIFORM MF COUNT/100mL	-	0				0	0	0	0	0	0	0	0		

TABLE 5.0: (cont'd.)

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						1984	14						DWSP	DWSP DRINKING
BACTERIA (Cont.d)	JAN	82	HAR	APR	нау	JUNE	JULY	AUG	SEPT	100	VON	DEC	LIMIT	LIMIT* GUIDELINE
TREATED WATER: (Cont'd)														
FECAL COLIFORM MF COUNT/100mL													0	DOWO Bacti
STANDARD PLATE COUNT MF  COUNT/ I ML	0	7	0	m	13	1580	86	436	64	22	е	4		
IF PRESENT/ABSENT TEST POSITIVE:														
Total Collform 1-4/100 mL	-													
FECAL COLIFORM P/A														
E. COLI P/A														
AROHONAS P/A														
STAPH. AUREUS P/A														
TOTAL COLIFORM BACKGROUND  COUNT/100mL	-													

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= see individual footnotes for Agency of guideline origin
```

- = California State Department of Health Action Level
- owno for DDI (contains other isomers such as OPDDI and PPDDI)
- USEPA ambient guideline
- United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains
- = USEPA proposad maximum contaminant level for drinking water other isomers)
- suggested Health and Walfare Canada/Ontario Ministry of the Environment guidaline value
  - world Health Organization (WHO) guideline
- World Health Organization (WHO) Odour Ihreshold mg/L = milligrams per litre, parts per million, (ppm)
- Presence/Absance = microbiological tast to indicate presence or absance of coliform bacteria ng/L ≈ nanograms per litre, parts per trillion, (ppt)

# = raw water

- = Treated Orinking Water
- ug/L = micrograms per litra, parts per billion, (ppb)

ODWO Interim maximum acceptable concentration, (IMAC)

- New York State (Taste and Odour) proposed drinking water guideline
- total Tribalomethenes
- combined total: Haptachlor and Heptachlor Epoxide
- if other than DWSP Detection Limit
  - total of Aldrin and Dieldrin
- = Chiordene is a mixture of siphs and gamma isomers
- Ministry of the Environment and Health and Welfare Canada, (IMAC)



	- 3-YEAR SUBBIARY
SO-JA	WATER QUALITY .
	GRIMSBY
	PLANT

Page 1

	=		1986			1985			1984			و1		DWSP	DWSP DRINKING
AAL CHEMISIRY	_	МАХ	X	AVE	НАХ	N	AVE	МАХ	N	AVE	МАХ	N	AVE	LIMIT	LIMIT* CUIDELINE
GENERAL CHEMISTRY	_														
H9/L 1	æ -	103	93	99.2	144.4 92.2 102.2 90.0 73.0 84.3	92.2	102.2 84.3	900	93	96.7			,	0.2 #9/L	
Total R mg/L 1	œ <b>-</b>				0.112	010.0	).112 p.010 0.047 0.111b.008 0.046	0.111	800.0	0.046				0.05 mg/L	-
H H H H H H H H H H H H H H H H H H H	<b>x</b> -		-											0.1 #97L	
R 1/6=	æ F	36.6	42.0 16.0 36.6 24.8	27.0	27.0 31.12 22.11 26.59 29.41 23.73 26.49 29.7 32.00 24.00 27.3 32.00 26.00 27.4	22.11	26.59	29.41	23.73	26.45				0.2 #9/L	250 mg/L
ACU R	œ =	45.0	1.5	9.1	31.0	2.5 10.3 0.5 0.8	10.3	12.5	2.2	5.7				0.5 1CU	5 1CU
CONDUCTIVITY R	œ ►	397 374	313	341	354	323 328	336	351 376	320	331				0.01 UMH0/CH	
FIELD CHLORINE (COMBINED) R mg/L	æ -													0.1 mg/L	
FIELD CHLORINE (FREE) R mg/L T	æ =-													0.1 #9/L	
FIELD CHLORINE (TOTAL) R #9/L T	α F	-												0.1 mg/L	
* -	α -													0.2	

DRINKING	LIMIT* CUIDELINE		1 F TU	2.4		U	10 mg/L 88 N	1 mg/L 88 N	0.15 =9/L		
OWSP	UE TECTION			0.01 #9/L	0.5 mg/L	0.05 mg/L	0.05	0.005 #9/L	0.1 =9/t		0.01 1/6
	AVE										
5	Z Z										
	MAX										
	AVE				132 134	-	0.5380.3870.456	.0227,0062 .0112 .0310 .0028 .0138	0.34	8.3	.0338.0015.0116 .0156 .0019.0057
1984	Z				121 135		n.387	.0028	0.23	8.2	.000
	МАХ				147		0.538	.0310	0.75	8.5	.0156
	AVE			·	131.8 147 132.6 146			.0112	0.532 .228 0.343 0.75 0.23 0.34	8.60 7.91 8.23 7.907.30 7.57	.0116
1985	ž				123 126			0062	.228	7.91	.0015
	НАХ				139			.0227	0.532	7.90	.0338
	AVE				136 136					8.2	
1986	X				126 130					8.1 7.1	
	MAX		_		148					8.3.4	
	GENERAL CHEMISTRY (CONT. d)	FIELD TEMPERATURE R	FIELD TURBIDITY R	FLUORIDE B9/L	HARDNESS R9/L T	MACNESIUM B9/L T	NITRATE #9/L T	NITRITE B9/L T	NITROGEN TOTAL KJELDAHL R	æ	PHOSPHORUS FILTERED REACTIVE T

	25.	INE 1											۰,
Page 3	DRINK	CUIDE				- 2			0.05	1 19/L		5 119/L	0.005 mg/L
	DWSP	LIMIT* CUIDELINE	0.01	0.1 mg/L	- 1 10 10	0.01 FTU		0.003 mg/L	0.001 mg/L	0.001 mg/L	0.001 mg/L	0.02 mg/L	0.0003 mg/L
		AVE											
	-61	HIN											
		¥											
		AVE	0.048			12.22							
	₹ 1	Z.	0.011										
		MAX	0.215			29.8 2.0 0.39 0.12							
		AVE	0.160 0.012 0.046 0.215 0.011 0.048			13.79							
	19.85	X	0.012			1.69							
		МАХ	0.160			35.8 1.69 13.79 0.40 0.12 0.19							
		AVE				9.55							
	1986	N				2.25							
_		XX				23.3 2.25 0.56 0.11	-		Δ				
( <del>.</del> 6	F		<b>α</b> ⊢	<b>α</b> ⊢	æ ⊢	<b>α</b> ⊢		<b>α</b> ⊢	<b>α</b> ⊢	æ -	α ⊢	~ ⊢	α <b>-</b>
TABLE 5.1: (cont'd.)		GENERAL CHEMISTRY (Cont'd)	PHOSPHORUS TOTAL =9/L	1/6 <b>e</b>	80L10S #9/L	UTN		M mg/L	7/6m	1/6m	IUM mg/L	1/6 <b>m</b>	# mg/L
			рноsрнс	S001UM	TOTAL SOLIDS	TURBIDITY	METALS	ALUMINUM	ARSENIC	BARTUM	BERYLLIUM	BORON	CADMIUM

TABLE 5.1: (cont'd.)

HITALS (CONT'4)   HAX   HIN   AVE   AVE   AVE   AVE   AVE   AVE   AVE   AVE		S-1					- 5						
#FIALS [cont.4]	DRINKING	WATER 08J	0.05 mg/t		1 19/L	0.2 mg/L	0.3 m9/L	0.05 mg/L	0.05 mg/L		1/60		
#FIALS [cont.4]	DWSP	LIMIT	0.001 mg/L	0.001 =9/L	0.001 mg/L	0.001	0.002 =9/L	0.003	0.001 =9/L	0.001 =9/L	0.01 ug/L	0.002 mg/L	
#FIALS (cont.4)		AVE			1								
1985   1984   1985   1984   1985   1984	5	Z I						-					_
#F7ALS (Cont'd)  #9/L 1  #8/L		$\Box$											-
#F7ALS (Cont'd)  #9/L 1  #8/L		AVE					.025						
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)	1984	ž					0.05						-
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)		ж					1.64						
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)		AVE					3.08						=
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)	1985	z					0.03						
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)		НАХ					18.50						
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)		AVE					0.326						=
1 1/6 (Cont.d) HETALS (Cont.d) B HETALS (Cont.d)	1986	ž					0.005						
#F7ALS (Cont'd)  #9/L 1  #8/L		НАХ					0.040						
_		S (Cont.d)					α ⊢						=
CHROH IUN CORALT COPPER LEAD HANGARESE MOLYBDEROW HERGURY		HETAL	1/6■	1/6	₩9/L	1/6	<b>™</b> 9/L	1/6∎	1/6		1/6n	1/6	
			CHROMIUM	COBALT	COPPER	CYANIDE	IRON	LEAD	MANGANESE	HOLYBDENUM	MERCURY	NICKEL	

TABLE 5.1: (cont'd.)

DWSP ORINKING	LIMIT* GUIDELINE							0/0.1	200	_		° OWDO Bact I
ā	בֿ ב	0.1 ug/L	0.1 ug/L					•	•			•
	AVE							_				
٤ ا	2											
	X											
	AVE					1080	32600	146				0
1984	Z					22	136	2				0
	МАХ					8800	125380	1507				2
	AVE					509	21090125380 136	99				27
1985	2					2	267	2				0
	HAX					3229	8008	142				321
	AVE					20 535	64713676 80080 267	15				100
1986	2					20		2				0
	HAX					2583	66475	84				800
		~ -	<b>~</b> -			~	Œ	~	Œ		P P	-
	MASS SPEC. (Cont'd)	TE TRACHLORBUTANE Ug/L	TETRACHLOROBIPHENYL ug/l	BACTERIA	RAW WATER:	TOTAL COLIFORM MF count/100mL	TOTAL COLIFORM BKGD COUNT/100mL	FECAL COLIFORM MF COUNT/100mL	STANDARD PLATE COUNT MF COUNT/ IMU:	TREATED WATER:	PRESENT/ABSENT TEST	TOTAL COLIFORM BACKGROUND MF COUNT/100mL

		1986			1985			1984			اع		DWSP	ORINKING
BACIERTA (CONT. 0)	МАХ	ž	AVE	МАХ	Z	AVE	МАХ	2	AVE	MAX	N.	AVE	LIMIT	LIMIT* GUIDELINE
TREATED WATER: (Cont'd)														
FECAL COLIFORM MF	_			0	0	0							•	ОМОО
count/100mL								-						Bacti
STANDARD PLATE COUNT ME COUNT/IML	-			482	2	51	1580 0.0		184			,		
IF PRESENT/ABSENT TEST POSITIVE:														
Total Collform 1-4/100 mL														
FECAL COLIFORM P/A														
E. COLI P/A														
AROMONAS P/A	-						-							
STAPH. AUREUS P/A														
TOTAL COLIFORM BACKGROUND  COUNT/100ML														

- = see individual footnotes for Agency of guideline origin
- = California State Department of Health Action Level
- OWDO for DDI (contains other isomers such as OPDDI and PPDDI)
- = USEPA ambient guideline
- United States Environmental Protection Agency (USEPA) ambient level for endosulfan (contains
- USEPA proposed maximum contaminant level for drinking water

other (somers)

- = suggested Heaith and Weifare Canada/Ontario Ministry of the Environment guideiine value
- = World Health Organization (WHO) Odour Threshold

World Health Organization (MHO) guideline

- mq/L = milligrams per litre, parts per million, (ppm)
- ng/L = nanograms per litra, parts per trillion, (ppt)
- Presence/Absence = microbiological test to indicate presence or absence of coliform bacteria

= raw water

- Treated Drinking Water 11
- = ODWO interim maximum acceptable concentration, (IMAC)
- ug/L = micrograms per litre, parts per billion, (ppb)
- New York State (Tasta and Ddour) proposed drinking water guideline
- total Irihalomethanes
- combined total: Heptachlor and Heptachlor Epaxide
  - if other than DWSP Detection Limit
- total of Aldrin and Dieldrin
- Chlordane is a mixture of aipha and gamma isomers
- Ministry of the Environment and Health and Welfare Canada, (IMAC)



## TABLE 6

WATER PLANT OPTIMIZATION STUDY "MICROBIOLOGICAL QUALITY"



TABLE 6.0: MICROBIOLOGICAL QUALITY - RAW WATER (µg/L)

TAB	TABLE 6.0: MIG	MICROBIOLOGICAL QUALLI	CAL VORDI	ı	,	(2 (64)
	•	MOE WE	MOE WPOS PROTOCOL		Page 1 of 1984	7
		Chlor-a	a Chlor-b	Chlor-a	Chlor-b	
JAN.	Max.		5.1	3.1	0.4	
	Min.	8.0	0.3	1.6	0.5	
Ī	Avg.	4.0	1.8	2.3	0.3	
	No. Tests	S	20	m	ო	
FEB	Max.	4.5	3.4	8.1	3.4	
:	E .	2.7		3.0	0.4	
_	Avg.	3.4	2.4	5.6	1.5	
	No. Tests	4	4	e	3	
MAR	×	134.0	4.6	6.8	9.0	
-	Hin.	2.9	2.4	1.3	0.1	_
_	Avg.	36.3	3.2	4.6	0.4	
	No. Tests	4	4	4	4	
APR	Max	19.5	25.9	9.4	1.7	
	Min.	4.4	0.7	2.0	0.2	
		7.3	7.3	7.2	0.8	
	No. Tests	4	4	5	5	
MAY	Max.	4.4	1.1	13.0	0.8	
_	Min.	2.6	0.5	5.1	0.4	
		3.6	0.8	8.1	9.0	
	No. Tests	5	5	2	5	
NO.	Max.	3.8	0.8		3.0	
_	Hin.	2.7	0.5	2.1	0.2	
		3.2	9.0		1.1	
	No. lests	4.	4	4	4	
-						

			1985	261	70 7 01	
		Chlor-a	Chlor-b	Chlor-a	Chlor-b	_
			1			_
J J	- Max.				1.7	_
	Hin.	2.0	0.4	2.5	9.0	_
	Avg.			•	1.1	_
	No. Tests	50	2		4	
OILA	3				1	
900	. Tak			7.		
	A.G.	0,0	; ·	0.0	4.0	
	No. Tests	• 🕶	• 4	4	• 4	_
						_
SEP	Max.	5.4		5.4		_
	<u>.</u>	2.1	9.0	2.3		_
	Avg.	4.2		3.3	٠	_
	No. lests	5	r.	4	4	
00 T	Max.				1.0	
	¥.	1.7	0.4	1.7	9.0	_
	Avg.	• 5		• (	8.0	
	10. 15313	7	4	n	3	
Š	Max.	•		9.9	6.4	_
	Hin.	1.2	0.5	3.8	0.4	
	No. Tests	• ന	• ന	3.0	3.0	
וני	X		!			
-	Min.	0.5	0.5	3.7	0.10	
	Avg.	• 1	•	6.2		
	NO. PESTS	٠	٠ 	<b>-</b>	m	

## TABLE 7

WATER PLANT OPTIMIZATION STUDY "BACTERIOLOGICAL TESTING"



TABLE 7.0: BACTERIOLOGICAL TESTING 1986 (No. Of Analyses Per Category)

MOE WPOS PROTOCOL

FEB MAR APR

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JUL AUG SEP OCT

ΝON

DEC NOTE:

JAN

		l#	100			FECAL	100	٠		FECAL	STREP	1	
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	4	۷	۷								,		
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:		2	2			m	-			2	2		
;	. 2	4	-			rv				4	-		
:	. m	2				2				~		-	
i	4	4				4							
1	2	2				7	2						
:	4	4				m	-						
!	2	2		<u> </u>		ru							
!	4	2	-			7							
:	4	٣	-			m							
!		-	۳			2	2						
1 %	All results	are	7	100 mL san Absent 1-100 101-5000	samples; E E F 700 G		carr1	tests carried out = 0-10	at -1-1-50 >50	E lab,	Resol	MOE lab, Resources Road.	Road.
			~ = 0	> 2000									



TABLE 7.0: BACTERIOLOGICAL TESTING 1985 (No. Of Analyses Per Category)

MOE WPOS PROTOCOL

JAN

FEB MAR APR JUN JUL

_		TOTAL	1703			FECAL	1703			FECAL	STREP		_
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~	Γ.	2	2	L.		2	2			2	7	-	
- ]	4				-						-		
~		2	2			7	7			7	2	1	
- 1	4				-	-				-	-		
~⊢	m		2			2					7	1	
∝⊢	4	3	-			e	:			П	2	П	
~ ⊢	4	4	<b>-</b> -			4				4			
~⊢	4	ъ				٣				ε			
~ F	5	4				5					e l		
<b>~</b> ⊢	4	Э	ч			г	3				4		
~ F	2	4				2				r.			
~ F	4	٣	2			4	-			П	3		
« F	4		е	1			4				3		
~-	 m	1 2	4			4	1				2		
A11 r	results	are		100 mL se	samples;		carri	et o	, at	MOE lab,	, Resources Road.	rces	Road.
			A B D D	Absent 1-100 101-5000 >5000			0-10 11-500 >500		2-50 >50				

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JAN MAR MAR

														. paq.
Ī	5		-			н			-					Resources Road.
STREP	_	3	т	4	4	-	2				2		2	Resour
FECAL STREP	Ξ					ъ	2	S	т	е	٣	2		MOE lab,
	¥													at 2-50 >50
	9		н											led out H = I = J =
100		1	н	2		1	2	 	2	П		П	2	tests carried out = 0-10 H = 0 = 11-500 I = 3 = >500 J = 3
FFCAL COL	_	2	7	7	4	4	2	2	7	٣	2	٣	-	
	V								<u> </u>					ples
	6		-	<u>.</u>	<u> </u>	<u> </u>		<u> </u>	<u> </u>	<u> </u>				100 mL sar Absent 1-100 101-5000
1			7		-	-	2		-	-		٦	2	for 100 B = 1 C = 10
TOTAL		m	-	۳	8	4	-	2	m	٣	2	٣	-	are
	4	4						3	۳	4	2	4	2	results
		æ	<u> </u> ~ –		« r	~-	<u> </u> ~ –	e -	« r	~ <b>-</b>	~ <del>-</del>	<u>«</u> ⊢	~ <del>-</del>	E .

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MOE WPOS PROTOCOL

TFCAL COL1 COL1 COL1 TFEB R 6 T 7 HAR R 7 T 7 HAR R 7	701AL C0L1 302 0 1056 1056	33 33 31 31	107AL C0L1 358 0 573	FECAL COL1 7 1507	10TAL COL1 27 0	FECAL COLI	107AL COL1
<u> </u>	302 0 1056 0 0	33	358 0 573	1507	27		_
<u>                                   </u>	1056	31	573	1507			
MR R 7	213	39			2220		
(PR   R   3	0		454	28	348	1	
	118	142	734	9	72		
MAY R 84	2583	2	6 0	21	188		
JUN R 2	5e 0	7	20	45	8800		

	I	1986 1 TOTAL	FFCAI	1985 TOTAL	FECAL	1984 TOTAL	1983 FECAL 1 TOTAL
- 1	100	100	COLI	1700	COLI	COL I	
∝ ⊢	12	0 33	2	80	2	44	
~ <b>-</b>	10	24 0	14	92 0	75	490 0	
~⊢	7	20 0	2	90	6	74 0	
~⊢	7	609	12	313	4	22 0	
~⊢	S	263 0	9/	3229 0	32	452	
<b>~</b> ⊢	27	1169	7	323	15	239	

APPENDIX D
TERMS OF REFERENCE

	420		

## Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

## Work Tasks

- Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.
- 2. Document the quality and quantity of raw and treated waters.
- Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.
- 4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.
- Assess current disinfection practices and possible improvement methods.
- Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.
- 7. Prepare a draft report for the project committee's review.
- 8. Prepare the final report.

RECEIVE AN INFORMATION PACKAGE FROM THE MOE. 1. INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED. TO DISCUSS THE PROJECT.

- (a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.
- (b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.
- (c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more than one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

#### Elements of Work

- (a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.
- (b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.
- (c) Document the methods of measuring the raw and treated water flow rates.
- (d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/ iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

# Document the source and methods used in determining all information.

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0). For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

# Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

## Document the source and methods used for all data provided.

- (h) Document the water sampling systems (source, pump, line-material and size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).
- (i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.
- (j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

 DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE,

- (a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.
- (b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.
- (c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.
- (d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.
- (e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.
- (f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).
- (g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD LITTLETE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION. ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

- (a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.
- (b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.
- (c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.
- (d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).
- (e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

 ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

- (a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.
- (b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.
- (c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.
- (d) Evaluate the feasibility of the various alternatives using the existing plant capital works.
- (e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

- (a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.
  - It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.
- (b) Incorporate (a) above in the draft report.

 PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

## Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

- (b) Meet with the Project Committee on site at least one week after submission of the report.
- (c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

- (a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.
- (b) Amend the report as per review comments, incorporating additional field data if required.
- (c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.

